AUGUST 1, 1911.

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POWER

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THREE GOOD REASONS FOR USING

ALBANY GREASE

ONE: Albany Grease is the best lubricant *for all moving* parts of MACHINERY.

TWO: Albany Grease *does not drip*—no drippings, saves on your INSURANCE; Albany Grease is wasteless, lasts longest and is CHEAPEST in the end.

THREE: Albany Grease *never gums* and absolutely REDUCES friction.

When you buy Albany Grease, look for this mark. It is your protection.

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Adam Cook's Sons, Proprietors

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Let Us Loan You A Dean For A Thorough Trial In One Boiler

WE want you to find out what condition your tubes are in—they may be a good deal dirtier than you think. Then we want you to see that you can do your boiler cleaning in less time, with greater ease and at smaller cost with a Dean than you can with anything else.

The Dean Boiler Tube Cleaner

goes where no inspector can—makes no mistakes—tells the truth—never leaves you in doubt.

It leaves the tubes through which it passes as clean as gun barrels.

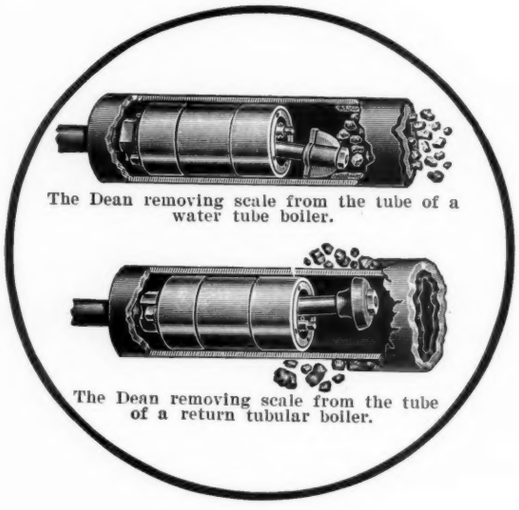
It cleans 10 to 30 tubes an hour and never injures a sound tube.

The Dean may be used in Fire Tube and Water Tube boilers where the size of the tubes is the same by changing the style of vibrator head.

Why not try a Dean?

It s the logical way of removing scale and it is guaranteed to pay for itself in six months' use or your money back.

Let us loan you a Dean for free trial in one boiler.



The Dean removing scale from the tube of a water tube boiler.

The Dean removing scale from the tube of a return tubular boiler.

The Wm. B. Pierce Company

Jewett Building, Buffalo, N. Y.

Chicago Office: 801 Steinway Building

POWER

Vol. 34 NEW YORK, AUGUST 1, 1911 No. 5

IN all probability, Chief, there is in your plant a young man in a black shirt and greasy overalls, a dark smudge under one eye, his arms covered with dirty oil to the elbows. Perhaps his eyes are snapping with the pleasure of his first association with machinery.

He had always longed for the time when he could "get close to the wheels"; as a little kid he hung around the power-house door, and nothing short of turning the hose on him could drive the boy away.

And now his boyish dream has come true; he is one of "the men."

What are you going to do for him, Chief? Will you hark back to the days when *you* were a kid? Will you put yourself in his place and take him in hand and give him the benefit of your own dearly bought experience? Do you intend to keep a watchful eye upon him and guide the boy in the path from which, perhaps through neglect, you many times strayed? Will you so instruct him in his duties and exercise a firm, kind discipline over him that in the days to come he will rise to hights where he may be a credit to his instructor and an honor to his calling?

He is now an unknown quantity—the algebraic x. In the future the young man may be your manager or your superintendent; nobody knows.

Will he then have good reason to give you a warm grasp of the hand and say he has not forgotten what he owes to his old chief for the thorough training and kind words of counsel? This would be something of which to be proud.

So very much depends upon starting this young man properly. If he is made of the right stuff, he will early reflect credit upon you, and you will be given credit for having set him upon the right track.

Times have changed from the days when roughness and severity "ruled the roost"; when a man to succeed had to fight every inch of the way if he would rise above the disgruntled, the sloths, the plodders.

To bring out and develop the best that is in him, the young man of today must see an intelligent reason for what he is assigned to do, and you should be his instructor, Chief.

Do not discourage and dishearten him by neglect and undue severity. It is very true that a power plant is no nursery where the young man must be petted and coddled; it is a school wherein the student is expected to learn and profit by what he has been taught; to understand that he owes a duty to his chief and to his employers, and must render full value to them.

It is up to you; will you help him?

Richmond's New Municipal Plant

By Edward T. Binns

New hydroelectric plant with 20-foot head to supply arc lighting and motors in pumping station. Auxiliary steam turbine plant installed as a reserve.

For many years the city of Richmond, Va., has purchased electrical energy for street lighting from a private corporation. Of late there have been about 1000 arc lights, which have cost the city $56 each, making a $56,000 lighting item.

Another problem which came up for consideration was that of the city's water supply. As suburban districts had built up along the river in the direction of the water supply, the city's needs outgrew the capacity of the old pumping station, and a new one was built some eight miles up the James river. It was equipped with motor-driven centrifugal pumps capable of delivering some 20,000,000 gallons, or an increase of nearly 50 per cent. over the old station.

One of the objects of erecting the new municipal plant, which is now nearing completion, was to furnish energy for the new pumping station.

The dam for the water supply extends from the north shore for nearly a mile in a diagonal direction to the old Bell Isle prison island.

The new station will use water power, and the accompanying photographs will serve to convey an idea of the dam, breastwork, gates and flume for bringing the water to the wheels. The intake gates were fitted up by the Colvill & Willcox Company.

The development provides for a 20-foot head. Three 5-foot Morgan-Smith low-head wheels have been installed and arrangements are being made for a fourth. Lombard governors regulate the speed within 3 per cent. variation. The gates in the draft tubes are of the wicket type and are operated by the governors through a train of gears. They are provided with dashpot relay attachments to guard against overrunning.

General Electric 60-cycle generators are direct connected to the waterwheels. They are of the revolving-field type and have a capacity of 425 kilovolt-amperes at 150 revolutions per minute. Two motor-driven exciters furnish direct current at 125 volts for field excitation. The motors in the pumping station are of the induction type and use alternating current at 4000 volts.

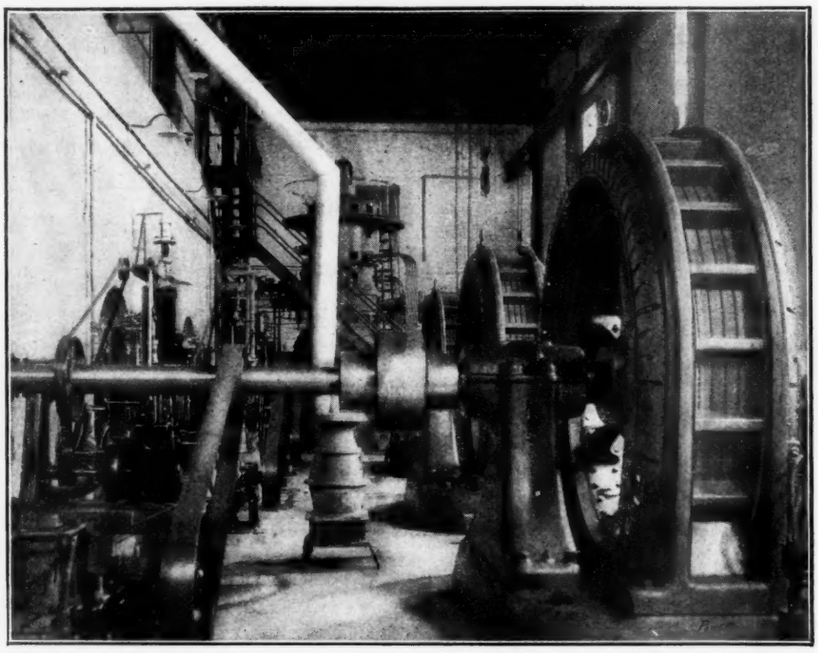


FIG. 1. GENERATING ROOM OF RICHMOND PLANT

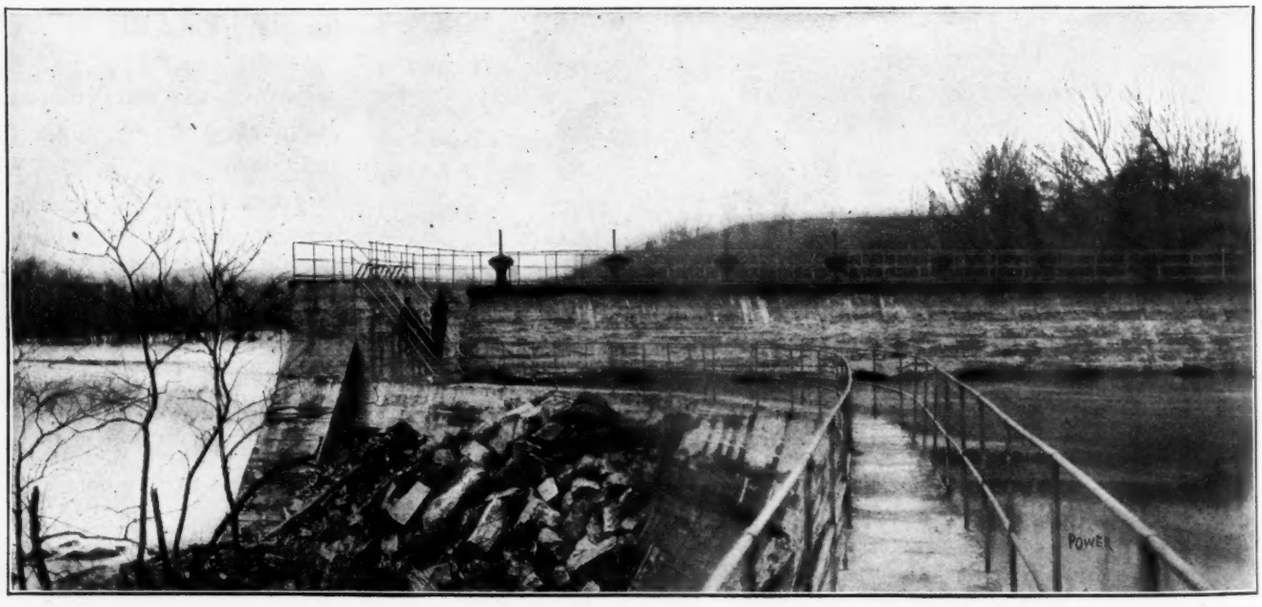


FIG. 2. DAM, BREAST GATES AND FLUME

To provide for possible emergency, steam equipment has been installed sufficient to take care of the station load. The boiler room contains two 500-horsepower Babcock & Wilcox boilers with the usual boiler-room auxiliaries. There are two Curtis turbines of the vertical type direct connected to revolving-field alternators running 1800 revolutions per minute. The condensing outfit consists of two Alberger barometric condensers placed outside the building and provided with both circulating pumps and a siphoning attachment from the station supply in the forebay. The dry-vacuum pumps are of Laidlaw-Dunn-Gordon make.

The switchboard presents an attractive appearance. It is composed of 32 panels of blue Vermont marble mounted upon a framework of piping. Upon the five generator panels are mounted the usual complement of horizontal edgewise and Thomson meters. The field rheostats are mounted directly above the panels and are plainly visible in the view of the switchboard. The two three-phase feeder panels which control the four 150-horsepower motors at the pumping station are shown in the picture as nearest the observer.

Eleven panels make up the arc board which is equipped with oil and open and short-circuiting plug switches. The wiring system is arranged on the three-phase, four-wire plan. The busbars are in duplicate and all oil switches are of the double-throw, double-pole type, and are so arranged that any generator or feeder may be thrown on either bus. Each feeder panel has connection through a 100-light General Electric transformer.

Although no figures are available, it has been stated that the new plant will supply the arc lights and the motors in the new pumping station at an annual expense considerably less than the cost of running the old pumping station.

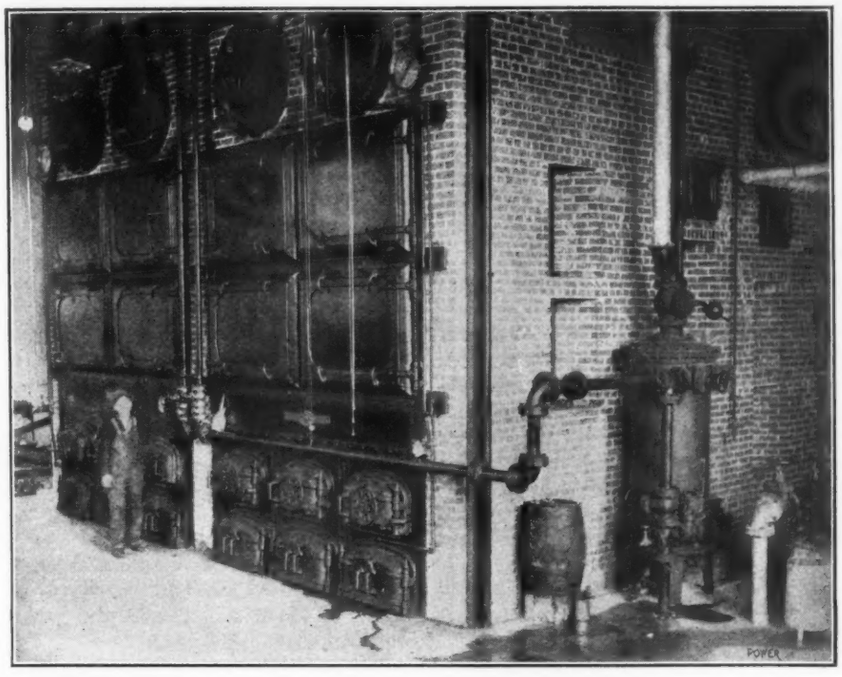


FIG. 3. BOILER ROOM OF AUXILIARY STEAM PLANT

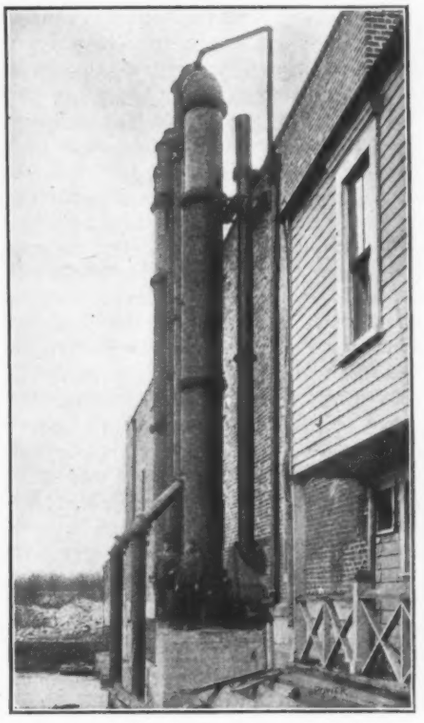


FIG. 4. ALBERGER BAROMETRIC CONDENSERS

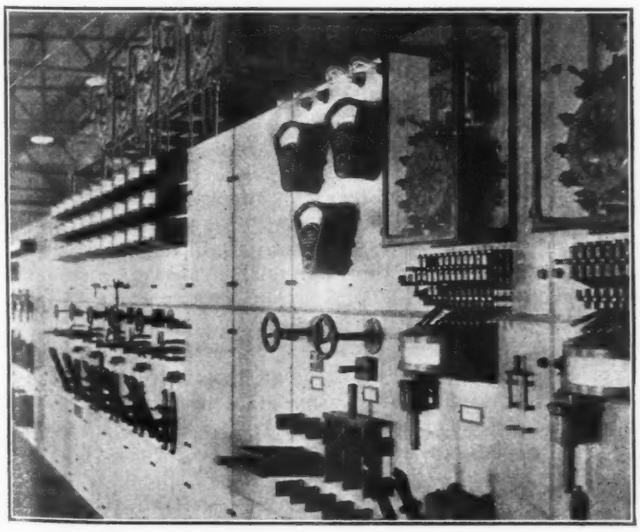


FIG. 5. SWITCHBOARD OF 32 PANELS

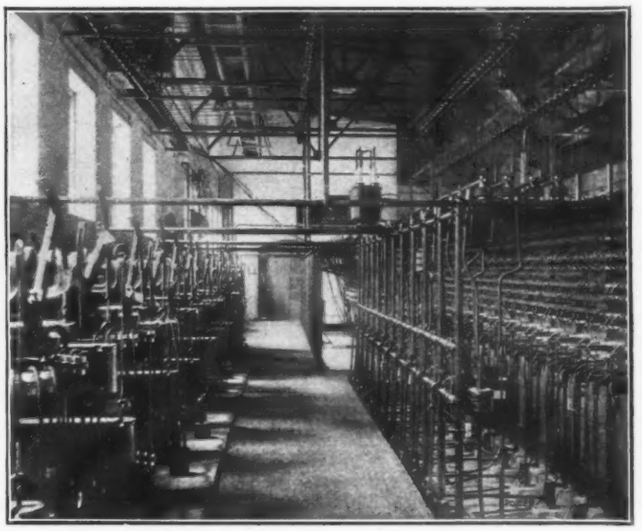


FIG. 6. BACK OF THE SWITCHBOARD

Determining the Value of a B. T. U.

By Julian C. Smallwood*

The fixing of a standard heat unit and a resume of the work of various investigators in determining the mechanical equivalent of a British thermal unit.

*Associate professor of experimental engineering, Syracuse university.

Heat may be measured in two ways: by the use of a definite quantity of heat as a unit, or by measuring the amount of mechanical work to which it is equivalent. Prior to the nineteenth century heat was generally believed to be an invisible material which bodies soaked up, just as a sponge would take up water. It was not known that heat was convertible into work or work into heat according to a definite law. Toward the end of the eighteenth century, however, Rumford denied the materiality of heat. He reasoned that if it were a material it might be entirely removed from a body as all the water may be squeezed from a sponge, and if this were not the case the material theory would fail. He rubbed together two pieces of iron under water, the temperature of which he measured, and observed that as long as the rubbing was continued, heat was generated. It followed that, as the heat was produced by motion which required energy, it must be a form of energy and perhaps motion. Between 1800 and 1840 this theory gained ground until, in 1842, Mayer and Joule separately established the fact that heat had a definite value in terms of work and that the one could be transformed into the other. Since then the so called "kinetic" theory of heat has slowly developed and is now generally accepted.

This theory states that heat is a manifestation of the molecular motion of matter and that heat and mechanical energy are identical.

Although the early physicists were uncertain as to the nature of heat, they knew that to measure it intelligently, three conceptions were necessary, namely, those of mass, temperature and heat capacity. Thus, a pound of iron at 100 degrees would raise the temperature of a quart of water more than the same weight of iron at 200 degrees would a bucketful of water. More heat was added to the bucketful, but the temperature rise was less because the amount of water heated was greater. It was recognized that a large amount of a substance at a low temperature may contain more heat than a small amount of the same material at a high temperature. Temperature was found to be a measure of heat intensity which, taken with the mass, fixed the quantity of heat; just as voltage is a measure of current intensity and, taken with amperage, determines the electrical energy.

As a natural development, the heat of a body was measured by noting its effect upon the temperature of a known mass of another material, water being the standard for comparison. A rough unit then was the amount of heat required to raise the temperature of a unit mass of water one degree.

Experiments showed that the amount of heat corresponding to a rise of one degree in the temperature of a unit mass was different for different substances. This led to the conception of "specific heat." It was found that this quantity was different not only for different materials, but for the same material it varied slightly with the temperature; this applied especially to water.

From the foregoing it will be seen that, for a definite heat measure, a standard

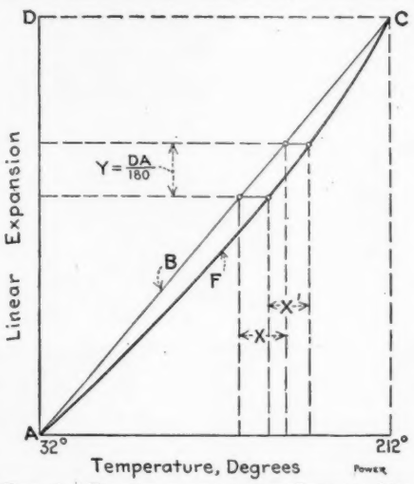


FIG. 1. RELATION BETWEEN LINEAR EXPANSION AND TEMPERATURE

unit of mass, a standard unit of temperature and a material at a standard specific heat are necessary.

The English unit is a mass whose weight is one pound. This is based upon a copy of the standard kilogram of the archives of France. Upon the legalization of the metric system in the United States in 1866 the pound was defined by act of Congress as the relation,

$$2.2046 \textit{ pounds} = 1 \textit{ kilogram}$$

This made the kilogram the fundamental standard, following the practice of other countries which had previously adopted the metric system. It was later found that the relation

$$2.204622 \textit{ pounds} = 1 \textit{ kilogram}$$

was more accurate and this is now taken as the standard.

Regarding the unit of temperature, the standard, although definitely fixed, is not so well established. It was early found that as materials were heated they increased in volume. It appeared also, in most instances, that such expansion was uniform for equal additions of heat. Hence, the natural conclusion was that the increase in the length of a material was a measure of heat intensity. Accordingly, the mercury thermometer was devised, mercury being chosen on account of its expansive qualities. The Fahrenheit scale of degrees was chosen in a roundabout way by its inventor who exposed his thermometer first to freezing water and then to water at the boiling point. He marked the stem of the instrument at the level of the mercury in each case, and divided the distance between the marks into 180 equal parts. Each part he called a degree and then continued the scale below the freezing point by 32 of these divisions. The freezing point thus became 32 degrees and the boiling point 212 degrees. Therefore, the Fahrenheit degree may be defined roughly as the increase in temperature corresponding to 1/180 of the total linear expansion of the material chosen for a thermometer, between the freezing and boiling points of water.

In a thermometer whose material expands uniformly with an increase of temperature, the relation between linear expansion and actual temperature in degrees would be as shown by the straight line *A B C* in Fig. 1. The distance *Y* would then correspond to 1/180 of the temperature between 32 and 212 degrees, as shown by *X*. A thermometer whose material does not expand uniformly would follow some relation such as shown by the curve *A F C*. The two instruments would record the same at the freezing and boiling points, and they would each have 180 equal divisions called degrees; but any one of these divisions, as *Y*, on the scale *A F C*, would correspond to an actual temperature *X'*, as compared with *X* and the scale *A B C*.

No known material expands according to the ideal relation shown by the line *A B C*. The departure from it, although slight, is appreciable in accurate work. Also, different materials expand according to different laws. If, however, the linear expansion of a particular material, such as mercury, were alone the measure of temperature it would yield a definite though arbitrary, scale, because the expansive properties of such a material when pure, are constant.

In a mercurial thermometer, however, the degree is not measured by the expansion of the mercury only; the glass containing it also expands. The scale, therefore, depends upon the relative expansion of mercury and glass. The latter varies considerably both in manufacture and in expansive properties, so

that for a standard scale it must be specified with great care.

Owing to the difficulty of obtaining glass with identical qualities, it was sought to reduce its influence upon thermometric indications by using as a substitute for mercury, a material whose total expansion would be very great compared with that of the glass. For the

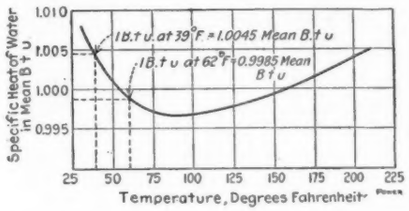

Specific Heat of Water in Mean B.t.u.
1.010
1.005
1.000
0.995
1 B.t.u. at 39°F = 1.0045 Mean B.t.u.
1 B.t.u. at 62°F = 0.9985 Mean B.t.u.
25 50 75 100 125 150 175 200 225
Temperature, Degrees Fahrenheit
Power

FIG. 2. VARIATION OF SPECIFIC HEAT WITH TEMPERATURE

expansive material, air was commonly used among the early investigators; later, nitrogen and hydrogen came into more extensive use.

Gas thermometers are of two types: constant pressure and constant volume. The former uses the expansive properties of the fluid as in the mercury thermometer, while the latter measures the temperature indirectly by the pressure which varies directly as the temperature, according to Boyle's law. The resulting scales are different, but this difference is so slight (their variations being but a fraction of a degree) that for most engineering purposes it is not necessary to discriminate between them. The gas scales are very nearly coincident with each other and with the theoretical work scale devised by Lord Kelvin. The mercury scale, however, is higher than the others between the freezing and boiling points of water.

The nitrogen scale is the one commonly employed in scientific work, but the standard (between the freezing and boiling points) is that of the constant-volume hydrogen thermometer. This was defined in 1887 by the International Bureau of Weights and Measures. The standard instrument is operated at an external pressure of one standard atmosphere, or 760 millimeters of mercury, and the hydrogen is maintained at a pressure (when at the freezing point) of one meter of mercury.

It has been previously mentioned that the specific heat of water varies with the temperature. It follows that, to be precise, the heat unit must be based upon a particular temperature range. Unfortunately several such ranges have been chosen for this purpose. Among the earlier investigators, the freezing point was adopted as a standard temperature from which to measure, and the unit of heat was that amount necessary to raise one pound of water from 32 to 33 degrees Fahrenheit. Later, another temperature was chosen, that at which a given weight of water has the least volume, namely, about 39 degrees. It became apparent, however, that both were inconvenient temperatures at which to take heat measurements; hence, 62 degrees was chosen. Lately, there has been a tendency favoring still another unit, the mean B.t.u. This is the average amount of heat per degree required to raise a pound of water from the freezing to the boiling point.

The curve* in Fig. 2 shows the relation between the specific heat of water, in mean B.t.u., and temperature. From it can be obtained the relation between the various units mentioned, and it is seen that

$$1\ (62\ degrees)\ B.t.u. = 0.9985\ mean\ B.t.u.$$

In the United States all three units are in common use. For some reasons, the mean B.t.u. seems the preferable quantity. It is independent of the thermometric scale since it is fixed by the two temperatures which are the same on all scales, and therefore is more precise.

Turning now to the work measure of heat, this involves the conception of the foot-pound, and the units of length and

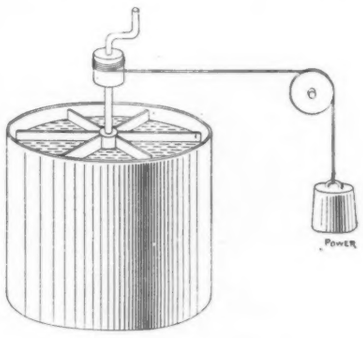


FIG. 3. DEVICE FOR MEASURING MECHANICAL EQUIVALENT OF HEAT

force. The standard foot was fixed by the same act which established the unit of mass, and is defined by the relation

$$1\ meter = 39.37\ inches$$

the meter being that of the archives of France.

Force is usually measured by the action of gravity upon a standard mass. It is the product of the mass and the acceleration of gravity at the location considered. But the action of gravity (that is, the acceleration) varies with the latitude and the hight above sea level. Hence, a definite unit of force must clearly define the location at which it is standardized. At the third general conference of weights and measures at Paris, in 1901, this was done, and the standard acceleration of gravity was named as that at sea level and 45 degrees latitude, or 980.665 centimeters per second per second. This in English units is 32.174 feet per second per second.

To convert the measurements of force made with a standard mass at any other location into standard units, it is necessary only to divide this force by the existing acceleration and multiply by the standard acceleration.

The electrical unit of work may also be mentioned, since heat has been measured in this unit, which is the joule, or the work done in one second by one ampere of current against a resistance of one ohm. Joules may be converted into mechanical units by the following relation:

$$1\ joule = \frac{2.204622 \times 0.3937 \times 10^7}{980{,}665 \times 12} =$$

$$0.7375\ standard\ foot\text{-}pounds$$

The work measure of heat is dependent primarily upon the establishment of the mechanical equivalent; that is, the number of foot-pounds equivalent to one B.t.u. This constant can be determined only by experiment. Fig. 3 illustrates a method by which it may be measured. A falling mass is arranged to churn a definite weight of water, and the temperature rise due to churning is noted. The work done by the weight is thus directly converted into heat. Knowing the work done and the heat resulting from it, the number of foot-pounds equivalent to one B.t.u. may be calculated.

If this apparatus is applied to raise the temperature of the water, degree by degree, and the work done for each degree rise is calculated, the resulting values will show the variation of the specific heat of water. Fig. 4 shows the probable variation of the mechanical equivalent of one degree rise of a unit mass of water with the temperature. The mean hight of the curve, shown by the dotted line, is the value of a mean B.t.u.

It is not an easy matter to measure these quantities with precision. During

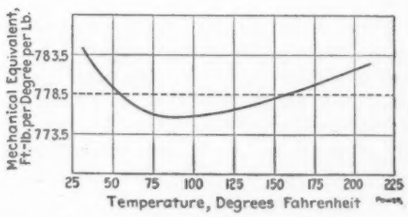


FIG. 4. VARIATION OF MECHANICAL EQUIVALENT WITH TEMPERATURE

the last sixty years there have been at least nine valuable investigations (and many others of minor importance) to determine the mechanical equivalent of heat, and each result differs from the others by amounts which, although small, are important. The early investigators were beset with difficulties, principally because of the crude apparatus and their comparative ignorance of the physical properties of materials. Of late years,

*This curve represents the average of slightly differing values found by a number of investigators, as combined by Marks and Davis.

however, several independent investigations have made the value of the equivalent reasonably certain.

The first to furnish a value for the mechanical equivalent of heat was Professor Mayer, who, in 1842, published a determination depending upon the specific heat of air. He calculated the work done by its expansion in a closed cylinder while being heated. Then, knowing the amount of heat required to raise the temperature one degree (no external work being done) and the similar amount of heat transferred during the actual expansion, the mechanical equivalent was calculated by equating the difference of these quantities to the work done. As the data available at that time were not accurate, Mayer's estimate was also inaccurate.

About the same time, Doctor Joule, of Manchester, Eng., was making independent experiments along the same lines. Between 1843 and 1845 he published the results obtained by three different methods: First, by measuring the heat generated by the current from a small dynamo and the work necessary to drive it; second, by a water churn similar to that illustrated in Fig. 3, and, third, by experiments on air along the same lines as Mayer had worked. One of these results was a very close approximation; the others varied from it by 10 to 15 per cent. In 1850, Joule published his first determination of real value. This was obtained by an apparatus similar in principle to that shown in Fig. 3. The weights were alternately raised and lowered, and observations were made of all conditions affecting the test, which was repeated many times. After making all corrections, such as allowances for friction, radiation, absorption of heat by the vessel containing the water, etc., Joule came to the conclusion that the mechanical equivalent of heat was 772 foot-pounds at Manchester for each B.t.u. at about 60 degrees on the mercury scale.

About a quarter of a century later, Joule made another determination by electric measurements. The heat produced in a known resistance by a known current was equated to the work equivalent of the current. By this method his result was so different from his first value that he was led to repeat the water-churning experiment. In 1878 he published his final result, which agreed closely with the experiment of 1850, being 772.5 Manchester foot-pounds for each B.t.u. at 60 degrees on the mercury scale. His apparatus for this test was much the same as before except that, instead of using weights, the work was measured by a device in principle like Fig. 5. This is similar to a prony brake, the paddle being revolved by hand. The work done is proportional to the rate of turning and to the force necessary to hold the vessel stationary.

The next to investigate the mechanical equivalent of heat was Professor Rowland, of Johns Hopkins University, who, in 1878, repeated Joule's work on a larger scale. The tests were conducted at Baltimore, to which latitude the results were referred. He employed an apparatus similar in principle to that shown in Fig. 5, but very elaborate in the perfection of its mechanical details. The paddle was revolved by a small steam engine and the measuring apparatus was a model of refinement and delicacy. Mercury thermometers were used which had been standardized by comparison with an air thermometer which, in turn, was corrected to give temperatures on the work scale.

Rowland's investigation covered a larger temperature range (from 41 to 97 degrees) than Joule's and his results were higher. His value at 58 degrees was 779.2 foot-pounds at Baltimore per B.t.u. on the absolute scale. He compared his results with Joule's and showed that after the latter's had been corrected for latitude and the differences in the

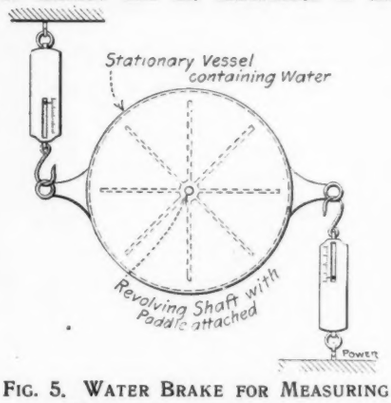


FIG. 5. WATER BRAKE FOR MEASURING MECHANICAL EQUIPMENT

thermometric scales, they were almost coincident with his own.

Another determination by water friction was published in 1897 by Professors Reynolds and Moorby. Their apparatus was similar in principle to that shown in Fig. 5, it being a water brake for a 100-horsepower engine. The water was heated, in passing through the brake, from 34 to 212 degrees and a large amount of it was used, the rate being varied so as to maintain the issuing temperature at 212 degrees. The mechanical equivalent obtained was 777.5 foot-pounds for each mean B.t.u.

A number of investigations have been made comparatively recently by means of electrical measurements, among which are those of Griffiths (1893), Schuster and Gannon (1895), and Callendar and Barnes (1902), the last named being the most notable. The method here employed was to heat a continuous stream of water from 32 to 212 degrees by a measured current. The result, as published, is 4.186 joules per mean calorie, or about 777.8 standard foot-pounds per mean B.t.u.

Professor Smith, of the University of Michigan, has corrected Reynolds' figure for the error involved in not starting at 32 degrees. The revised value is 777.6 standard foot-pounds per mean B.t.u. He also corrected Barnes' value for the e.m.f. of the Clark cell so that this result, as revised, is a little less than 777.5, the units being the same.

The accompanying table gives the revised results of the investigators mentioned in this article. The figures in the first column are in standard foot-pounds per B.t.u. at 59 degrees Fahrenheit, on the nitrogen scale. This scale is selected because most of the results are quoted in its terms. To convert the mechanical equivalent to terms of the standard hydrogen scale, it is necessary only to add 0.3. The second column gives the corresponding values expressed in mean B.t.u.

	Standard Foot-pounds per B.t.u. at 59 Degrees (Nitrogen Scale)	Mean B.t.u.
Joule (average result)..	776.6	777.3
Rowland.....	778.2	778.9
Griffith.....	779.0	779.7
Schuster and Gannon..	779.1	779.8
Reynolds and Moorby..	.....	777.5
Callendar and Barnes..	.....	777.6

Griffiths' and Schuster's results are higher than any of the others. In this connection it may be noted that they were obtained by the electrical method. This indicates a constant error in the electrical standards. On the other hand, Barnes' result, similarly obtained, is lower than all except Reynolds'. Griffiths worked between 59 and 78 degrees Fahrenheit and Schuster at 66 degrees only. The two determinations covering the whole range from 32 to 212 degrees are practically coincident. It appears, then, that the discrepancies may be due in part to errors in electrical measurements and to lack of knowledge of the variation of the specific heat of water.

Professor Peabody has adopted Rowland's value of 778 foot-pounds per B.t.u. at 62 degrees, whereas Marks and Davis have adopted Professor Smith's estimate of the mechanical equivalent. This is a mean between the corrected results of Reynolds and Moorby and Barnes.

It may be observed that the average of these results, omitting Griffiths' and Schuster's and Gannon's figures, which may have a common error, is 777.8. This agrees fairly well with Professor Smith's estimate.

It seems reasonable to give equal weight to all the results listed (except, perhaps, Joule's), Griffiths' and Schuster and Gannon's being included because of the extreme carefulness of their experimental work. The average value is then 778.5 foot-pounds per mean B.t.u. and the probable error is 0.3 foot-pound. The mechanical equivalent of heat, therefore, lies between 778.2 and 778.8; this estimate being dependent upon the translation of the value at 59 degrees to the mean heat unit.

The Combustion of Town Refuse

By Francis H. Davies

The primary function of a refuse destructor should be to dispose of refuse. The power obtained is a secondary consideration. Several types of destructor are illustrated and their operation discussed.

The sanitary and economical disposal of town refuse by cremation in a destructor is a problem that has engaged the attention of engineers for something like half a century, and during the last decade it has been complicated by the desire of turning to useful account the heat generated in the destructor. With the growth of towns both questions, particularly the former, become of some importance. It is no longer considered sanitary or even expedient to dump refuse on some unoccupied piece of land and to leave it to work out its own salvation by a process of decomposition; neither is it by any means so usual to deposit it in the sea, to employ it for manure or partially to cremate it in inefficient furnaces operating in connection with some private factory. Prior to the advent of the modern sanitary destructor these or like courses were necessary, but their unsatisfactory nature coupled with the fact that under favorable conditions the destruction of refuse may be carried out at a profit arising from the sale of the furnace residue and the useful employment of the heat, has resulted in the installation of a very large number of such plants.

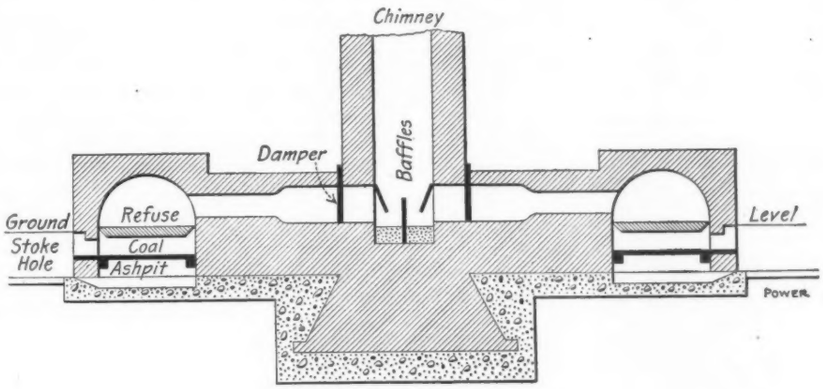


FIG. 1. BEEHIVE DESTRUCTOR

Primarily, the function of a destructor is to dispose of refuse; the power that may be obtained from the heat of combustion should be looked upon as a byproduct and not, as it has been in certain notorious failures, as the objective of the installation. In sound practice, therefore, the second consideration is to some extent subordinated to the first, and the destructor is designed primarily to deal with the refuse in a manner that is effective and inoffensive.

The quality of refuse varies within wide limits according to the district and time of year. A town in which there is a considerable wood-working trade or other industry employing material of high calorific value will naturally prove an easier proposition than one in which a good proportion of the refuse consists of incombustible and wet substances, such as scrap metal, crockery and vegetable matter. Likewise, since the cinders and ash from domestic hearths or stoves are generally present in good proportions, it follows that the refuse of the summer months may not be of equal value to that of the winter. However, this and similar points will depend entirely upon local conditions, and it is obviously impossible to generalize in a matter where special circumstances will carry so much weight.

According to Hutton the average composition of town refuse is as follows:

	Weight, Per Cent.
Breeze and cinder	50.0
Paper, straw, fibrous material and vegetable refuse	13.0
Coal	0.7
Bones and offal	0.6
Rags	0.4
Coke	0.3
Ash	12.0
Dust and dirt	20.0
Bottles, 1 per cent.; tins, 0.7 per cent.; metals, 0.2 per cent.; crockery, 0.6 per cent.; broken glass, 0.5 per cent	3.0
	100.0

It will be seen that the bulk of house refuse consists of good combustible material, but this, of course, does not represent the average quality of town refuse which will always contain a proportion of street sweepings and other substances of low calorific value. It is the presence of such low-grade material that has made efficient and hygienic cremation a difficult problem.

Under proper furnace conditions it is quite possible to deal effectively with any class of refuse so far as its destruction is concerned, but it is equally as important that the operation should not result in the production of smoke, dust and noxious fumes. In the early days this constituted the great trouble with destructors, and it will therefore be of interest to examine the steps taken to overcome this and other difficulties.

The rules which primarily govern the design of modern furnaces may be stated as follows: Furnaces or grates must be so arranged that they may be fired and cleaned alternately in order to keep the temperature as uniform as possible. It is also important that there should be a minimum influx of air during the operations of firing and clinkering, to prevent the temperature of the furnace falling too low. A combustion chamber of ample size and common to all the grates of one furnace or to the cells of separate furnaces, whichever system is employed, must be provided and, preferably, it should be placed between the fires and

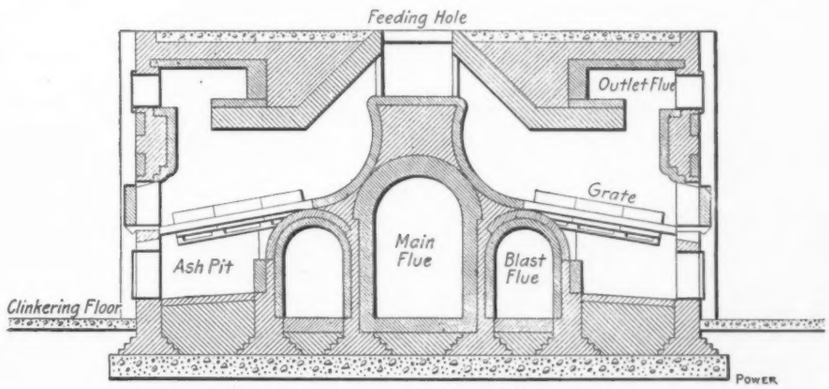


FIG. 2. HORSFALL DESTRUCTOR

the boilers where the latter are installed. Many destructors have been built with the combustion chamber after the boiler, the theory being that the latter will in that position be subjected to the greatest heat. This is no doubt true, but it is clear that the presence of a large and comparatively cool surface in close proximity to the fires will militate against efficient combustion of the gases, a portion of which may well pass through to

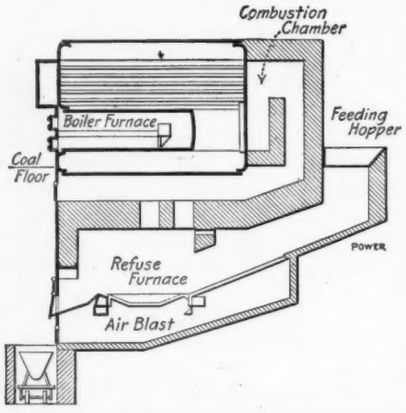


FIG. 3. BAKER DESTRUCTOR WITH RETURN-TUBULAR BOILER

the flues unburned and thus give rise to objectionable emanations from the chimney. There is obviously a difference of opinion on this point, and the system employed must be largely influenced by local conditions and the results it is desired to attain. In any case, the brickwork of the combustion chamber should be massive in construction in order that the largest possible amount of heat may be stored. At times of firing and clinkering the temperature of the furnace naturally drops, and heavy brickwork at a high temperature will tend to reduce this and generally to maintain uniform heat conditions.

The combustion chamber, besides fulfilling the important function of burning the gases, acts as a trap for the dust carried from the furnace by the draft. One of the great objections to destructor installations in the early days was the quantity of fine dust delivered from the chimney, and it is most essential if this nuisance is to be avoided that proper arrangements should be made for trapping it. It is also desirable from the point of view of boiler efficiency, since dust carried past the combustion chamber will partly settle on the tubes or heating surface of the boiler and seriously impair its steam-raising powers.

The question of draft is all important, and it is only by means of forced draft with a closed ashpit that efficient cremation of refuse can be effected. There are two methods in use for producing the blast, namely, steam jets and fans, and there is little doubt that the latter is preferable. The steam jet possesses the initial advantage of cheapness to install, and it is a generally accepted fact that the steam coming into contact with the incandescent fuel generates a water gas which helps materially in raising the temperature of the furnace. The chemical action is as follows. The steam is decomposed when it touches the fuel, the hydrogen being liberated and the oxygen combining with the carbon in the fuel to form carbon monoxide. The mixture of hydrogen and carbon monoxide, known as "water gas," then passes upward and is burnt by the excess air over the fire. A further benefit of the steam jet lies in its cooling effect upon the furnace bars. The steam is condensed by contact with the cool air it injects, and the resultant water is reëvaporated when it touches the hot furnace bars. The effect of this cooling is to prolong the life of the bars, and in some instances where fan draft is employed a small steam jet is also installed specially for this purpose.

The chief objection to the steam-jet method of producing draft is its cost. The percentage of steam taken may be anything from 10 to 20 per cent. of the output of the boiler, and this compares very unfavorably with the 4 to 5 per cent. required by steam-driven low-pressure fans. The choice between the two must be influenced by the value set upon the steam generated. If there is plenty of more useful work for it to perform it would be a mistake to waste such a high percentage in producing draft; but if, on the other hand, there is a good surplus and the boiler is always worked lightly, no object would be served by installing a comparatively costly fan outfit.

It is well known that a hot-air draft is preferable to a cold one in connection with furnaces, and this is particularly the case with destructors. It is therefore the custom to preheat the air, and one of the most effective systems is that shown in the part of Fig. 5 marked "regenerator." This consists of a series of tubes placed in the main flue, and the air which is drawn across their surface is thus delivered to the furnace at a temperature which may be as high as 400 degrees Fahrenheit above the atmosphere. Another method used in the destructor illustrated in Fig. 2 is that in which the air is preheated by being passed through side boxes placed between the grate and the brickwork. From the point of view of heating it is comparatively inefficient as the increase in temperature is something under 200 degrees Fahrenheit, but the fact that these boxes prevent the adhesion of clinker to the side walls of the furnace is important, as repairs to the brickwork are thereby reduced considerably. A disadvantage which this system in particular suffers from is that when the operation of charging is performed and the heat of the furnace is temporarily reduced the heat of the air supply is also lowered. This, of course, is exactly opposite to the most desirable condition which is that the temperature of the draft should be high directly after charging in order to assist in drying the refuse and igniting it.

A third system of preheating which has been introduced by Heenan & Froud is better in this respect since it affords the maximum of heat at the moment of charging. In the ordinary way the draft is heated by a regenerator, but after the fires have been clinkered it is, in addition, made to pass through a special pit beneath the grate in which the red-hot clinker lies, and by this means its temperature is materially increased, while the clinker is to some extent cooled and therefore more easily handled.

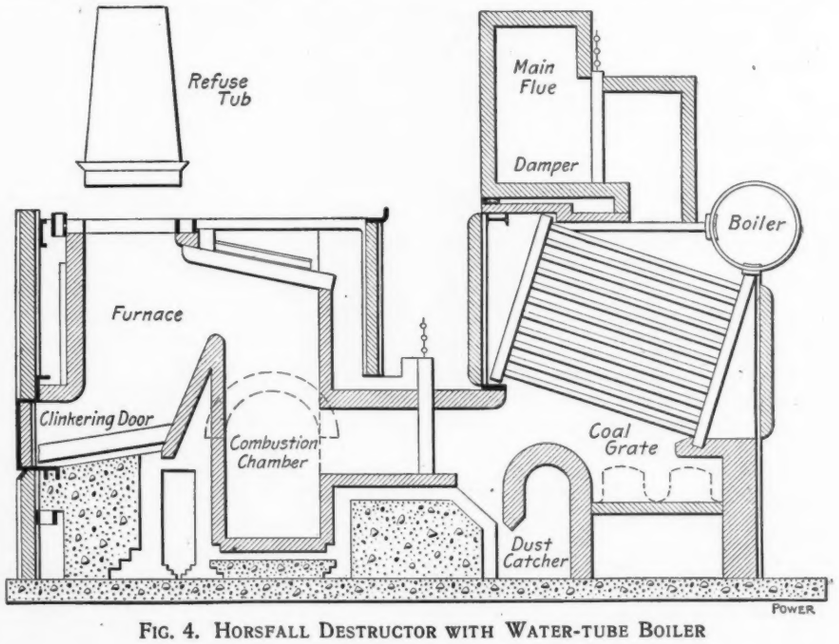


FIG. 4. HORSFALL DESTRUCTOR WITH WATER-TUBE BOILER

The intensity of draft is an important matter since it has an appreciable bearing upon economy. It varies in different installations from 1 to 6 inches of water column, and in cases is even higher. It is, however, not desirable to use a greater draft than is absolutely necessary, as with a high pressure there is always the possibility of blowing holes in the fire with resultant loss. Further, it must be remembered that increased draft means increased power absorbed in its production and, as previously pointed out, it is quite possible to carry this to a point at which the useful output of the boiler is seriously diminished.

The charging of destructors is generally performed by hand, in some cases either from the front or the back of the furnace by shovel, and in others through the furnace roof at the top. The alternative to these is mechanical charging, which, although involving some extra complication, is decidedly more sanitary. Hand charging of any sort besides being unpleasant and unsanitary possesses the disadvantage that a good deal of loss is occasioned through open fire doors by the influx of cold air. On the other hand, it is the only system by which it is possible to discriminate in the quality of refuse fed into the furnace, and this feature is a valuable one where steadiness of steam pressure is to be considered. In a mechanical system where each load as it arrives is dumped into the furnace by tubs or some such appliance, discrimination cannot be exercised, and while mechanical charging certainly scores upon the point of sanitation it is wanting in what is often the important one of easily regulated steam pressure.

Many of the difficulties met with in the design of destructors and a general idea of the various methods of operation will be gathered from the illustrations. Fig. 1 is a sectional diagram of a very early type termed the Beehive, and it is of particular interest as it shows that at that period it was not considered possible to maintain a fire with refuse alone. It will be noticed that to meet this difficulty a secondary grate for burning coal was arranged under the main grate, and the refuse on the latter was first stewed and dried by the coal fire and then more or less effectively burnt. This, of course, was a most undesirable process, since besides being costly it gave rise to dense smoke and objectionable smells, which indeed were so bad that some destructors of this type had to be shut down shortly after starting. The furnace was dependent upon a chimney only for its draft, and there was no combustion chamber other than the flues.

Fig. 2 shows a very different cell of a type greatly in use and known as the Horsfall destructor. The feeding hole is at the back of and above the furnaces, while the flue for the emission of the gaseous products is over the dead plate in front. The virtue of this construction is that the gases rising from the refuse must pass over the hottest part of the fire on their way to the main flue and thus be brought into contact with the extremely hot gases arising from the combustion of the incandescent material which has been raked onto the grate bars and is burning under forced draft. The cast-iron side boxes by means of which the draft is heated are shown adjacent to the grate.

The Baker destructor combined with a return-tube boiler is shown in Fig. 3. Here the boiler is placed directly over the refuse grate which is fed from the back through a hopper. Over the furnace is a reverbratory perforated firebrick arch, the heat of which assists in cremating the gases arising from the fuel. The gases flow through this arch and pass over the heating surfaces of the boiler, and it may be seen that there is a supplementary furnace in the boiler for burning coal which may be used when the supply of heat from the refuse is insufficient. When burning, this fire also assists in cremating the gases arising from the refuse. Clinkering is performed on the lower floor through a door in the front, arrangements being made for raking direct into a small trolley.

Fig. 4 shows a recent type of Horsfall destructor combined with a Babcock & Wilcox marine-type water-tube boiler. The refuse is fed by a special mechanical system through the hole in the top of the furnace, from whence it falls direct onto the grate. It will be noticed that an ample combustion chamber is provided between this and the boiler, and an efficient dust catcher is a special point of this type of cell. The path of the hot gases is across the boiler tubes and upward to the main flue, and a coal grate at right angles to the destructor grate is provided. This may be used in conjunction with the refuse furnace if desired, or by closing the damper midway between the two fires the boiler is isolated and may be operated in the ordinary way with coal. A feature of this destructor is the high-pressure blast, which may be carried to 12 inches water gage; it is found, however, that 6 inches is ample to meet average conditions. The air, which is heated by the side boxes above described and usual in destructors of this type, passes through numerous small holes perforated in the solid iron grate bars, and thus right into the burning refuse.

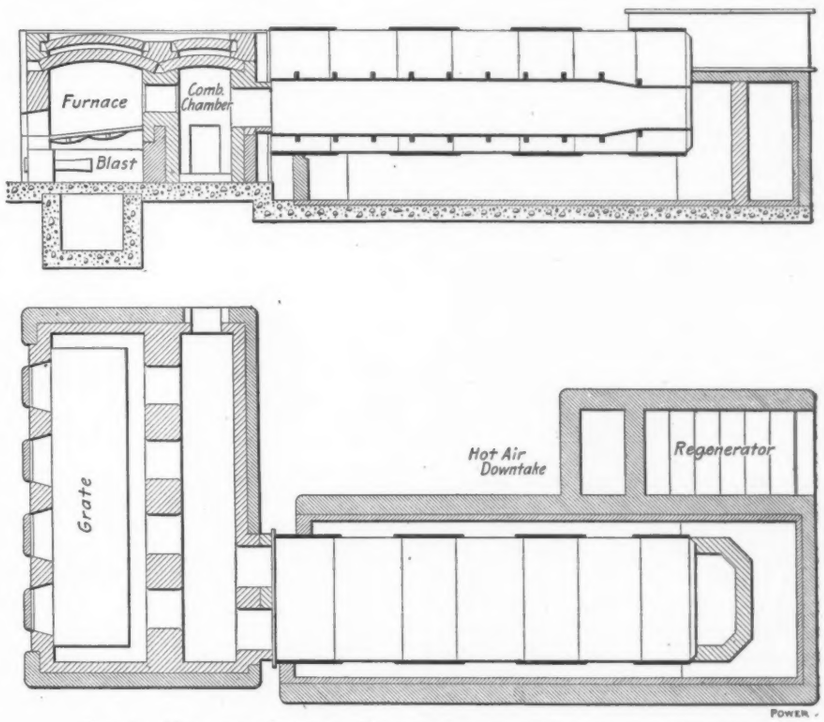


FIG. 5. MELDRUM SIMPLEX DESTRUCTOR WITH LANCASHIRE BOILER

The drawings, Fig. 5, show the Meldrum Simplex destructor in combination with a Lancashire boiler. The furnace grate is continuous, but each section or cell, as shown by the doors, is fired separately and each has also its own closed ashpit and forced draft independently controlled. By this arrangement the green gases given off by a newly fired section of the grate mix with the hotter gases from those sections which are in a more advanced stage of combustion, and being burnt by them do not appear in the form of smoke at the chimney. This design and method of working result in uniform temperature in the combustion chamber, a very important feature in the interests of sanitary opera-

tion and regular steam raising. The refuse is delivered close to the furnace doors by means of a hopper, and it is fired by hand. The regenerator previously mentioned consists of a number of cast-iron pipes through which the flue gases pass. The air for the blast circulates round the outside of these pipes and is thence delivered to the blowers by fans.

With regard to the amount of power it is possible to secure from the combustion of refuse in a properly designed destructor, there are so many variables which may enter into the case that it is of little use to generalize. However, the following table, showing the average vaporative power of town refuse, is given by Hutton, and it is of interest as indicating approximately what results may be secured.

Description.	Weight of water evaporated from and at 212 deg. F. per lb. of refuse fuel in lb.
Best screened ash-bin refuse	2.00
Average screened ash-bin refuse	1.50
Best unscreened ash-bin refuse	1.25
Average unscreened ash-bin refuse	1.00
Inferior unscreened ash-bin refuse	0.75
Unscreened ash-bin refuse, 2 parts, mixed with 1 part street sweepings, by weight	0.75
Unscreened ash-bin refuse 2 parts, mixed with 1 part street sludge, by weight	0.50

Further data taken from particular installations might be cited, but as they represent individually the results obtained under one particular set of conditions it is questionable if they would have much value. It is sufficient to say that there are numerous electric-power stations and industrial plants drawing a good proportion of their power from the combustion of town refuse, and, although some are failures financially, this is only the case where insufficient care has been given to the design or where a thorough examination of the local conditions if it had been made would have shown at the outset that, commercially, the proposition was unworkable.

Test with Oil Fuel*

Some important tests with oil fuel were recently conducted for the Government at the works of the Babcock & Wilcox Company, at Bayonne, N. J. The boiler tested was of the type to be installed on the new battleships "Wyoming" and "Arkansas" but was of smaller size. It had 2571 square feet of heating surface, a furnace volume of 271 cubic feet and a stack extending 100 feet above the burners. The grates were removed and the ash pans bricked over. Steam jets were placed in the stack to assist the draft and the closed fire-room system was employed.

A heavy, viscid Texas crude oil was used in eleven Peabody mechanical-atomizer burners. This oil contained about 19,290 B.t.u. per pound with a specific gravity of 0.9322 and had a flash point at 295 degrees Fahrenheit.

During the first three tests the draft was measured at the last pass, while in the three succeeding tests it was also measured at the first pass. Gas samples were taken from the uptake by means of a ¼-inch pipe leading to an Orsat machine.

The oil was run into weighing barrels direct from the tank cars and after being weighed was pumped to one of two receiving barrels. These two barrels were connected at the bottom by a 4-inch pipe, the oil-feed suction being led into the second barrel. The latter also received the overflow from the relief valves of the oil-pressure pump. From the top of this barrel the hight of the oil was measured by a gage, to determine the quantity burned. From the pressure pump the oil passed through strainers to the heater. At half-hour intervals the quantity of oil remaining in the barrel was checked.

The boiler was handled during the tests by experienced men in the employ of the company and all operations were closely supervised by the Government board.

The tests showed the desirability of making gas analyses at frequent intervals when burning oil; also of closely watching the temperatures of the uptake. Furthermore, it was found that the character of the smoke was an excellent guide to the results which were being obtained; in fact, changes in conditions were noted by the character of the smoke before they were apparent from the gas analysis.

During test No. 1 the maximum rate of combustion was attained, this being 13.69 pounds of oil per cubic foot of furnace volume per hour, or the equivalent of 75.34 pounds of coal per square foot of grate surface per hour.

OIL TESTS OF BABCOCK & WILCOX MARINE BOILER

Number of test	1	2	3	4	5	6
Duration of test, hours	2	3	3	4	3	3
Kind of oil			Texas crude			
Oil burner used		Peabod	y mecha	nical at	omizers	
Number of burners in use	11	8	4	3	8	8
Average Pressures						
Steam pressure by gage, pounds	209.9	210.4	210.7	212	214.8	214.8
Oil pressure by gage, pounds	191.1	188.8	175.6	131.3	153.2	171.8
Draft pressure in fireroom, inches of water	2.60	1.69	1.18	0.33	1.97	1.64
Draft pressure in furnace, first pass, inches of water	.....	.....	.....	0.65	1.35	1.65
Draft pressure near uptake, inches of water	4.83	2.10	1.64	0.72	2.58	2.79
Average Temperatures						
Outside air, degrees Fahrenheit	45.5	45	43	46	43	.....
Fireroom, degrees Fahrenheit	71.1	75.2	70.0	79.0	79.0	76.0
Steam (at gage pressure, tables), degrees Fahrenheit	391.5	391.7	391.8	392.3	393.4	393.4
Oil, degrees Fahrenheit	175.3	183.4	184.0	210.1	199.0	195.7
Feed water entering heater, degrees Fahrenheit	47	47	47	47	46	46
Feed water entering boiler, degrees Fahrenheit	168.6	160.9	201.0	211.2	185.6	182.8
Chimney gases, degrees Fahrenheit	771	666	533	447	702	630
Oil						
Weight of oil used during trial, pounds	5,943	5,112	3,605	2,665	5,767	5,840
Steam						
Quality, per cent	99.189	99.290	99.837	99.891	99.782	99.835
Water						
Total weight of water fed to boilers corrected for inequality of water level and steam pressure at beginning and end of test, pounds	74,898	67,036	53,464	40,096	75,714	83,753
Equivalent weight of water evaporated into dry steam, pounds	74,291	66,561	53,376	40,185	75,549	83,435
Factor of evaporation	1.096	1.104	1.062	1.052	1.078	1.081
Equivalent weight of water evaporated into dry steam from and at 212 degrees, pounds	81,423	73,483	56,685	42,276	81,449	90,193
Oil per Hour						
Oil per hour, pounds	2,972	1,704	1,202	666	1,922	1,947
Oil per hour per cubic foot furnace volume, pounds	13.69	7.85	5.54	3.07	8.86	8.97
Oil per hour per square foot of heating surface, pounds	1.156	0.663	0.467	0.259	0.747	0.757
Oil per hour per burner, pounds	270.2	213.0	300.5	222.0	240.3	243.4
Equivalent to coal per square foot of grate surface, pounds	75.34	37.45	28.34	16.13	43.96	46.14
Water per Hour						
Feed water per hour, pounds	37,449	22,345	17,821	10,024	25,238	27,858
Water per hour, corrected for quality of steam pounds	37,146	22,187	17,792	10,046	25,183	27,812
Equivalent evaporation from and at 212 degrees per hour, pounds	40,712	24,494	18,895	10,569	27,149	30,064
Equivalent evaporation from and at 212 degrees per square foot of heating surface, pounds	15.83	9.53	7.35	4.11	10.56	11.69
Equivalent evaporation from and at 212 degrees per cubic feet of furnace volume, pounds	187.60	112.87	87.06	48.70	125.10	138.53
Economic Results						
Water evaporated per pound oil, pounds	12.60	13.11	14.83	15.04	13.13	14.31
Equivalent evaporation from and at 212 degrees per pound of oil, pounds	13.70	14.37	15.72	15.86	14.12	15.44
Flue Gas Analysis						
Carbon dioxide, per cent	9.85	9.26	11.57	11.86	10.71	10.94
Oxygen, per cent	6.46	7.68	4.50	4.08	5.18	4.73
Carbon monoxide, per cent	0.01	0.00	0.04	0.04	0.02	0.00
Nitrogen, per cent	83.68	83.06	83.89	84.02	84.09	84.37
Efficiency						
Efficiency of boiler	69.29	72.68	79.50	80.21	71.41	78.08

*Abstracted from report in the *Journal* of the American Society of Naval Engineers.

Design of Steam Power Plants

By William F. Fischer

The factors to be taken into consideration when selecting an engine for a given service, and the characteristics of various types of engine.

Selection of Steam Engines

The selection of a suitable type of engine for a steam-power plant is governed by the location of the plant and that of the engine, the character of the service for which the engine is required, the cost of fuel delivered at the plant, the cost and quality of water available for boiler-feed and condensing purposes, available floor space, class and number of men necessary to operate and take care of the plant, the first cost of the engine, interest, depreciation and probable repairs.

It would be useless to select a high-priced engine for the sake of economy in the use of steam if the engine were to be used for a short time only, or over short periods of time. In such a case the economical use of steam is of secondary consideration as the interest, depreciation, first cost and increased cost of attendance, repairs, etc., might exceed the saving in fuel effected by the installation of the more economical engine. Where fuel is cheap or where a large quantity of exhaust steam is required for heating or manufacturing purposes, it would be poor economy to install an expensive and economical engine.

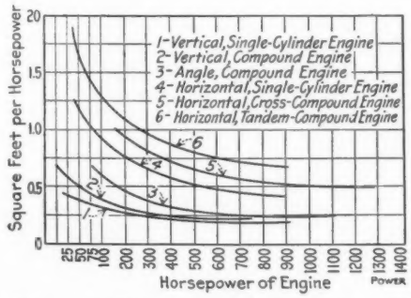


FIG. 1. FLOOR SPACE REQUIRED FOR DIRECT-CONNECTED UNITS

Another point worthy of consideration when selecting an engine is the time of delivery, as the expense involved in a long delay, including the interest on the idle investment, may be such as to more than offset the difference in cost between two makes of engines. Where real estate is expensive and the floor space is limited, engines of the vertical type are frequently installed in preference to those of the horizontal type, but as they require more headroom they are often undesirable in office buildings and hotel basements, etc.

Class for class, the steam economies of vertical engines and horizontal engines are practically the same, but in attendance and repairs the vertical engine requires closer attention.

When selecting an engine to drive an electric generator, care should be taken to see that the engine is neither too large nor too small for the generator. Each engine and each generator has its point of maximum efficiency as a combined unit; therefore they should be so selected and operated as to attain their maximum efficiencies at the same load. Ordinarily, the horsepower of the engine should be about 50 per cent. in excess of the generator rating in kilowatts.

It is customary for electrical purposes to make engines capable of developing about 25 per cent. overload when running condensing and full load when running noncondensing. In plants where the load is constant, or nearly so, the selection of an engine is a very simple matter, but where the load varies considerably the units should be selected with a view to operating each at its maximum efficiency during the greatest possible number of hours. For the sake of economy the engines should be of such capacities and so duplicated as to be put in and taken out of service as the load increases and decreases; and while in service each engine should be operated at its most economical load.

Engine Types

Simple engines are used largely for small high-speed units or where fuel is cheap. For larger units and in places where fuel is expensive, compound engines are generally used as the increased economy in steam consumption usually more than offsets the increased first cost. For steam pressures over 100 pounds per square inch and capacities over 150 horsepower, compound engines, whether operating condensing or noncondensing, will ordinarily save enough in fuel consumption to pay for their increased first cost. Moreover, the increased cost of the engine is partly offset by less boiler capacity being required.

Triple-expansion engines are seldom used for mill and electric-power plant service where the load fluctuates widely, as they rarely show a saving sufficient to warrant their use when the increased first cost, maintenance, etc., are taken into account. They are, however, used to a large extent in pumping stations where the load is practically constant over long periods. It is not desirable to operate a triple-expansion engine under less than 150 pounds steam pressure.

Engine builders usually arrange their patterns of the different sized engines so that each can be built with a number of different strokes. The purchaser may thus obtain an engine of long stroke and low rotative speed, or one of short stroke and high rotative speed.

High-speed Engines

All the early electric generators were belt driven and of small capacity and high speed, requiring comparatively small engines. As there grew a demand for units of larger capacity it was found inconvenient and cumbersome to belt from low-speed engines to high-speed generators; hence high-speed engines were introduced for direct-connected units. With engines of 100 horsepower or less, it is usually desirable for economy to employ an engine of moderately low speed and belt from the engine to the dynamo, providing there is sufficient floor space to accommodate the belted-type unit. In this instance, the loss due to the friction of the belt, which may vary from 5 to 10 per cent., is not sufficient to warrant the additional first cost of a direct-connected engine and dynamo. On account of the saving in floor space and in fuel, however, direct-connected units are preferable in sizes over 100 horsepower.

Modern high-speed engines have many advantages over the low-speed types. For a given horsepower they are more compact, require smaller foundations and smaller buildings than the low-speed type, and are, as a rule, simple in construction and easy to operate. On the other hand, although relatively low in first cost as compared to the low-speed type, they are subject to greater wear and tear and depreciate more rapidly. Also, they are usually less economical in steam consumption than are those of lower speed.

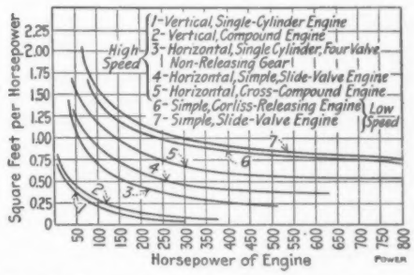


FIG. 2. FLOOR SPACE REQUIRED FOR BELTED UNITS

High-speed simple, single-valve engines of the self-oiling type are quite popular in hotels, office buildings and small manufacturing plants, and are also used to a large extent in small steam-power plants because of the few parts to get out of order, and the minimum

amount of attention required for their operation. They are seldom operated condensing, however, since in most cases the gain in fuel economy due to adding the condenser is more than offset by the extra cost of the condensing apparatus and its cost of operation and upkeep. This type of engine may be had in sizes up to 500 horsepower, but where fuel is expensive it is not advisable to install them in very large units unless the exhaust steam can be profitably used for heating or manufacturing purposes.

Single-acting Engines

Single-acting engines are used extensively for driving mechanical stokers, conveyers, etc. They are cheap and simple in construction and run at high speeds with little or no noise, depending on the care given them in operation. As a rule, they are much less economical in steam consumption than those of the double-acting type and are thus seldom used in large sizes or where fuel is expensive.

TABLE 1. PRESSURE RANGE FOR VARIOUS TYPES OF ENGINE

Type of Engine	Range in Steam Pressure, Pounds Gage	Average Steam Pressure, Pounds Gage
Simple low speed	60–120	90
Simple high speed	70–125	100
Compound high speed, noncondensing	100–170	130
Compound high speed, condensing	100–160	125
Compound low speed, condensing	125–200	150
Triple-expansion, condensing	140–210	175
Quadruple expansion, condensing	125–225	200

High-speed Multi-valve Engines

Modern four-valve engines show economies which approximate very closely those of the Corliss, medium- or low-speed types. These engines are built to operate at practically the same speeds as the single-valve high-speed type. The valves are designed very much on the same principle as the Corliss valve, but instead of being operated by a dashpot, are opened and closed by eccentrics on the main shaft. This valve gear is more flexible than that of the single-valve engines, resulting in a better distribution of the steam, closer regulation and less valve leakage. They require closer attention, however, because they are made up of a greater number of parts.

Compound Engines

Where fuel is expensive and exhaust steam is not required in large quantities for heating or manufacturing purposes, engines of 500 horsepower and over should, as a rule, be of the compound type. Besides requiring less boiler capacity than simple engines, they possess the advantage of a more uniform pressure on the crank pin which, in turn, produces a steadier turning motion on the crankshaft.

It is not considered good practice to operate a compound engine noncondensing, especially in the larger-sized units; but whether the engines of a plant should be run condensing or noncondensing depends upon several factors, including the capacity of the station, the nature of the load, the amount of water available for condensing purposes and the cost of pumping. Owing to the increased cost of condensing apparatus, piping, pumps, etc., and the increased cost of attendance it seldom pays to condense in very small stations. When selecting a noncondensing compound engine care should be taken to see that the engine is not too large for the average power to be developed as the expansion of steam in the low-pressure cylinder will be carried below the atmospheric pressure, when a light load is being carried. This results in the high-pressure piston dragging the low-pressure piston against the resistance of the atmosphere during part of the stroke, the unnecessary work thus performed resulting in a large waste of fuel. Care should also be taken to see that the cylinders are properly proportioned to equalize the temperature range in each cylinder if the best results are desired; due to this cause compound engines properly proportioned for condensing will be wasteful of steam when run noncondensing.

Rotative Speed

The terms "low speed," "moderate speed" and "high speed" as applied to steam engines refer to rotative speeds only. The piston speed of a low-speed engine, for example, might be considerably greater than the piston speed of a high-speed engine, due to the longer stroke of the former engine. The rotative speed at which an engine is to run is determined by the service for which the engine is required. If it is to be coupled direct to the shaft of an electric generator its design should conform to the speed of the generator, or the design of the generator should be adapted to the rotative speed of the engine. As a high-speed dynamo requires considerably less iron and copper in its makeup, and consequently weighs and costs less than a low-speed machine of the same power, high rotative engine speed is a desirable feature in direct-connected units.

The rotative speed is limited by the centrifugal force developed in the flywheel when in motion. Corliss and similar engines with releasing valve gears are not intended to run over 80 to 90 revolutions per minute; hence are never used for driving direct-connected generators of high rotative speed.

Piston Speed and Engine Regulation

A short stroke, besides permitting a high rotative speed and thus reducing the cost per horsepower of the engine and generator, also makes the unit more compact and requires a minimum floor space. Frequently in power-plant service the engine load is continually changing, and as any variation in engine speed may cause electrical disturbances on the system, it is of utmost importance that the speed should be kept uniform during all changes of load. Therefore, the governor regulation should be close under the most rapid fluctuations of load, and the valve gear should work well at any speed at which the engine will run with good results. The governing of engines for almost any kind of service is now sufficiently well known for engine builders to guarantee the required regulation. This point should, however, be made a part of the specifications for the engines. Voltage regulators are almost invariably used in connection with alternating-current work if both light and power are to be supplied from the same unit, or where voltage regulation is important. The voltage regulator in this case performs the same service for the generator that the governor performs for the engine.

Steam Pressure

Table 1, from "Gebhardt's Steam Power Plant Engineering," may be used as a guide in determining the steam pressure to be carried on the boilers for different types of engines. The average pressures ordinarily used are given in the second column of the table. In the larger steam stations, however, the tendency is toward the higher steam pressures as given in the first column.

TABLE 2. AVERAGE STEAM CONSUMPTION OF VARIOUS TYPES OF ENGINE AND THE GAIN BY CONDENSING

Type of Engine	Average assumed weight of steam per indicated horsepower per hour*		Gain by Condensing, Per Cent.
	Noncondensing	Condensing	
Simple low speed	29	20	31
Simple high speed	33	22	33
Compound high speed	26	20	23
Compound low speed	25	18	25
Triple-expansion low speed	20	15	20
Triple-expansion high speed	24	17	29

*Assumptions based on average practice.

Where a steam pressure over 150 pounds per square inch is to be carried more attention should be given to the design and erection of the steam piping, valves, fittings, etc., but as the higher pressure permits the use of smaller pipe sizes the cost of the piping will be sufficiently reduced to pay for a better class of piping material throughout.

Economy and Steam Consumption

In referring to steam-engine economy it is customary to state the economy in

terms of the number of pounds of steam consumed per indicated horsepower per hour, and in this respect the terms "steam consumption" and "water consumption" or "water rate," as it is sometimes called, are synonymous.

Table 2 shows the average steam consumption of various types of engines when operated condensing and noncondensing, and also the gain due to condensing. Much better results than these are very often obtained in actual practice with certain high-grade engines, but the table may be safely used for determining the necessary boiler capacity. The steam consumption of an engine will vary considerably, depending upon the conditions under which it is operated. It is, as a general rule, less expensive to overload an engine than to run it constantly underloaded.

The economy of a steam engine should never be stated in the terms "pounds of coal per hour" as this involves the economy of the entire plant, the quality and kind of fuel, the skill of the firemen, the efficiency of the boilers, etc., as well as the general design and care of the steam-piping system.

Figs. 1 and 2 show the approximate floor space required per horsepower for direct-connected as compared with that required for belt-driven units.

Smoke Prevention in Large Power Stations*

By H. S. Vassar

The steam demand in a central station is very different from that of a factory; the load is apt to fluctuate rapidly and sometimes as much as 50 or 60 per cent. of the boiler capacity must be "broken up" within perhaps 30 minutes.

Sometimes the sudden approach of a summer shower will so increase the lighting demand as to call for six or eight extra boilers in about as many minutes. Again an accident at a congested point in the street-railway system may cause a blockade that will relieve the load so promptly as to start all the safety valves blowing. Perhaps within a few minutes the load may return with an even larger demand for steam, and fires must be forced to meet it.

Other causes too numerous to mention might be given for the occasional erratic behavior of the load; it suffices to say that the modern central-station engineer is continually on the lookout for such changes and, so far as it is possible, strives to anticipate load variations by bringing up the banked boilers slowly, if time permits. But time is often lacking, and then, regardless of the smoke-preventing devices in use, the hurried breaking up of banked fires produces smoke.

*From a paper delivered before the International Association for the Prevention of Smoke at Newark, N. J., June 28, 1911.

One of the frequent structural difficulties with which many boiler plants, built up to six or eight years ago, have to contend is the small combustion space over the fire. Although this may be sufficient if hard coal is burned, it is usually lacking when bituminous or semi-bituminous coal is used. With a building designed for low-set boilers, it is often impracticable if not impossible to rebuild the furnaces for the use of soft coal, whether for hand firing or automatic stokers.

The ease with which a soft-coal fire responds to changes in steam requirements, together with the rapid rate at which it can be burned, makes it particularly desirable for central-station use. Moreover, hard coal, when the smaller sizes are used with forced draft, is open to the objection of the cinders being distributed over the surrounding area. This is considered by many almost as great a nuisance as soft-coal smoke. When it is necessary or desirable to use soft coal with these old settings, some of the numerous steam-jet devices will sometimes lessen the amount of smoke produced. The gist of the matter is that such a setting is absolutely unfitted for either smokeless or efficient operation with soft coal. For this reason, few of the large central stations of today build new furnaces without carefully considering the nature of the fuel to be burned and providing, to the best of their ability, the proper combustion space over the grate.

Efficient or smokeless combustion is more or less handicapped by hand firing, such firing requiring open fire doors during from 10 to 20 minutes of each hour when firing soft coal. Automatic stokers, however, are continually growing in favor; and, although each type has its own particular disadvantages, the gain in efficiency resulting from their use is a strong argument for their installation in almost any plant burning 75 tons or more per day. Some of the qualifications which should characterize the mechanical stoker for central-station use are:

1. Simple but substantial construction.
2. Small scrap pile.
3. No hand manipulation of the fire.
4. The rejection of a minimum amount of combustible with the ash.
5. Ability to burn varying grades of fuel economically at any rate up to 50 pounds per square foot of grate per hour, and to meet the varying steam demand promptly with a limited amount of skilled attention.

Little need be said relative to the first point. As to the second item, there are several stokers in use which require the frequent replacement of grates, dumps, etc., resulting in the accumulation of a large scrap pile as well as the expenditure of much labor, to say nothing of the frequent shutdowns for such repairs.

The matter of no hand manipulation of the fire is one of great importance. If barring by hand must be done to any great extent, either to secure proper air admission or for the removal of clinker, two of the most valuable gains due to automatic stoking are lost; namely, labor and efficiency, and excessive smoke invariably accompanies such handwork.

There is at present a movement for skilled boiler-room supervision, brought about partly because of a demand for the elimination of smoke, but to a larger extent as the result of an attempt to secure higher boiler-room efficiency. The principal reason for this increased attention to the matter of boiler-room operation is evident. The central station is in reality only a factory, its raw material being coal and its finished product electricity. In the older plants fuel constitutes from 40 to 60 per cent. of the cost of electrical energy at the switchboard and in later installations it is much higher.

A few years ago the boiler-room economy was supposed to be looked after by the superintendent or the chief engineer. These men, however, have enough on their hands in most stations without tackling, other than superficially, problems that are worthy of the undivided attention of at least one first-class man. By supervision is not meant an occasional trip through the boiler room, or a few maledictions heaped upon the heads of the firemen by a watertender; but continuous hour-to-hour supervision by a trained man whose principal duty is the economical burning of fuel.

Approximate Rule for Receiver Pressure for Equal Loads

The following approximate rule for finding the receiver pressure which should be carried in order that the indicated horsepower may be equally distributed between the two cylinders has been devised by Thomas Hawley, of the Hawley School of Engineering, at Boston:

Find the mean effective pressure by the usual method, using hyperbolic logarithms, for the whole number of expansions, assuming all the work to be done in the low-pressure cylinder.

As the low-pressure is to do only one-half of the work, divide by two, multiply this by the ratio between the cylinder volumes to get the mean effective pressure necessary for the high-pressure cylinder. By subtracting this from the mean pressure, as found by the hyperbolic-logarithm formula for the number of expansions in the high-pressure cylinder at full pressure, the back pressure necessary to give the required mean effective pressure in that cylinder is obtained. This will be the receiver pressure.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Operation and Connections of Alternators Working in Parallel

By Norman G. Meade

When operating alternating-current generators in parallel it must be borne in mind that if at any instant the electromotive force of one generator is lower than that of other machines with which it is connected, it will take current from the other generators instead of feeding current into the line. Furthermore, in order that the electromotive forces shall be the same, the generators must agree as to frequency, power factor and wave form; otherwise pulsating currents will be set up. When similarly designed machines are adjusted for the same voltage and operate uniformly at the same frequency, these conditions are usually fulfilled.

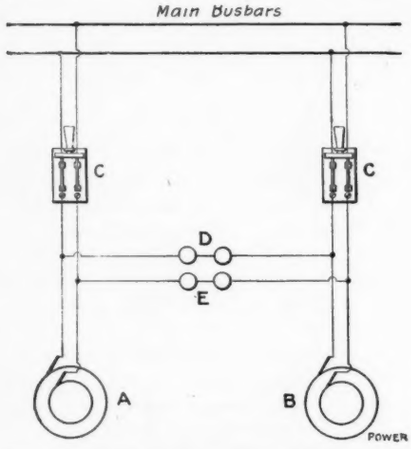


Fig. 1. Illustrating the Principle of Synchronizing

Speeds

The speeds of the engines should be adjustable while they are running in order that they may more readily be made to correspond when the alternators are being connected in parallel and that the load may be properly divided.

When machines are operated in parallel there is sometimes a tendency to non-uniform speeds, which may be due to any of several causes, such as a tendency to different speeds; unequal engine-speed regulation between no load and full load; irregular speeds, such as would be caused by a hunting action on the part of the governors, giving rise to a surging of load between the machines; irregular fluctuations of speed such as would be caused by lack of uniformity of angular velocity during a single revolution.

If the governors on the driving engines give different speeds it is evident that when two machines are in parallel that which tends to run at the higher speed will carry a greater proportion of the load until the governor is adjusted for a lower speed, when the second machine will begin to carry load. Before this condition is reached one generator may be running as a motor.

The governing of the speeds of the engines should be such that when running at a common speed they will deliver their proper amount of power. Alternators driven by engines governed closely between no load and full load are usually not as well adapted to running in multiple as those in which the regulation is not so close. In general the power delivered by a generator which is running in multiple with other generators is not dependent upon its field excitation but only upon the governor adjustment of the driving engine.

If a governor gives varying or irregular speed, first one machine and then the other will carry the greater load. The rapidity with which this change takes place depends upon the rapidity with which the governors oscillate in their running action. This tendency to varying speed is one of the most common sources of difficulty in parallel operation. When two direct-current dynamos are running in parallel, slight changes in their relative speeds, amounting to, say, ½ per cent. or so, would make very little difference in their operation. With alternating-current dynamos, however, the relation between speeds must be practically constant.

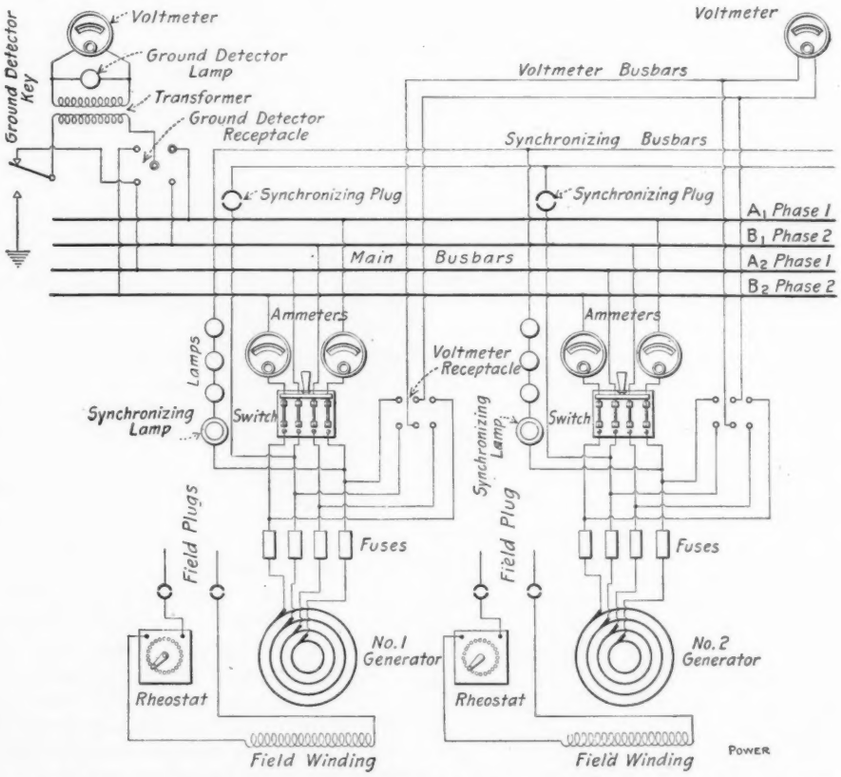


Fig. 2. Switchboard Connections of Two Low-tension Two-phase Alternators Operated in Parallel

Field Excitation

When the rheostats of two alternators running in parallel at normal speed are not adjusted to give proper excitation, idle cross currents will flow between the armatures; these depend only upon the difference in field excitation of the machines and they may vary over a wide range—from zero, when both field excitations are normal, to more than full-load current when excitations differ greatly. These cross currents increase the temperature of the armatures and, consequently, cut down the available output of the alternators. It is therefore important that the rheostats be so set as to reduce them to the minimum. Cross current is registered on the ammeters of both generators and usually increases both readings. The sum of the ammeter readings will be minimum when there is no cross current. In order to determine the best settings of the rheostats, therefore, it is necessary to make trial adjustments after the alternators are connected in parallel until the setting is found which reduces the sum of the ammeter readings to the lowest figure.

To illustrate this method, consider two similar alternators *A* and *B*, operating in parallel. When the rheostats of both are properly adjusted no cross current will flow through the armatures and the main ammeters will show equal readings if both machines are receiving the same amount of power from their respective prime movers. If the rheostat of *A* be adjusted so as to reduce its field excitation, a cross current, lagging in *B* and leading in *A*, will flow between the armatures, the effect of which will be to strengthen the field magnetization of *A* and weaken that of *B* until they are approximately equal. The resultant electromotive force of the system will thereby be decreased. A cross current of the same character is produced by decreasing the field excitation of one machine or increasing that of the other; that is, in both cases it will lead in the first machine and lag in the second machine. The electromotive force of the system will, however, be decreased in the one case and increased in the other.

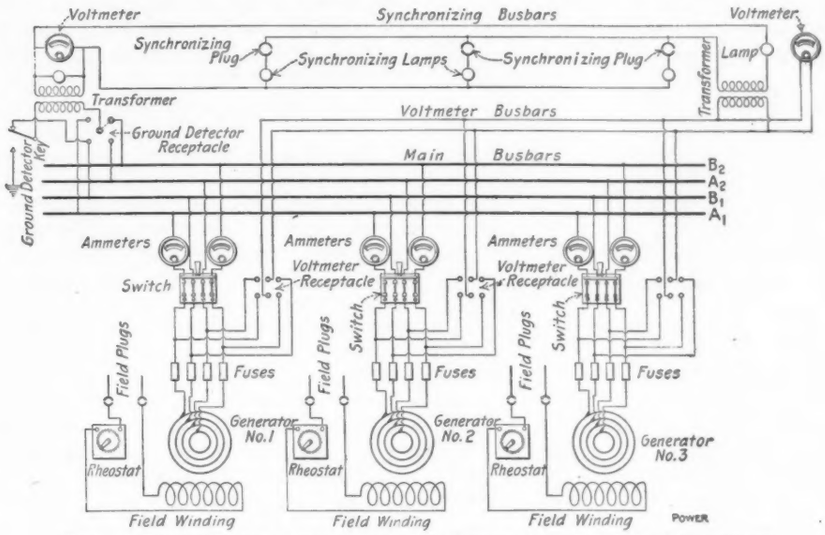


Fig. 3. Switchboard Connections of Three Low-tension Two-phase Alternators Operated in Parallel

From the foregoing statements it is obvious that by a combination of changes in the two rheostats, that is, by cutting one in and the other out at the same time, the cross current may be varied considerably while the electromotive force of the system remains constant.

For the first trial adjustment one rheostat should be cut in several notches and the other cut out the same amount, so as not to vary the electromotive force of the system seriously. If this reduces the sum of the main ammeter readings, the adjustment should be continued in the same direction until the lowest possible readings are obtained. After this point is reached a further adjustment of the rheostats in either direction will increase the ammeter readings. If the first adjustment increases the sum of the ammeter readings, it is being made in the wrong direction and the rheostat handles should be moved back slightly past the original positions and the adjustments in these opposite directions continued as just described.

In making these adjustments of the rheostats it may be found difficult to locate the exact points at which the cross current is minimum, as it may be possible to move the rheostat handle over a considerable range when near the correct position without materially changing the ammeter readings. When this is the case the setting is good enough for practical operation.

Synchronizing

The elementary principle of the method of determining when alternators are of the same frequency and are in phase is illustrated by the diagram, Fig. 1, in which *A* and *B* represent two single-phase machines the leads of which are connected to the busbars by the switches *C* and to each other through two sets of incandescent lamps *D* and *E*. It is evident that as the relative positions of the phases of the electromotive forces

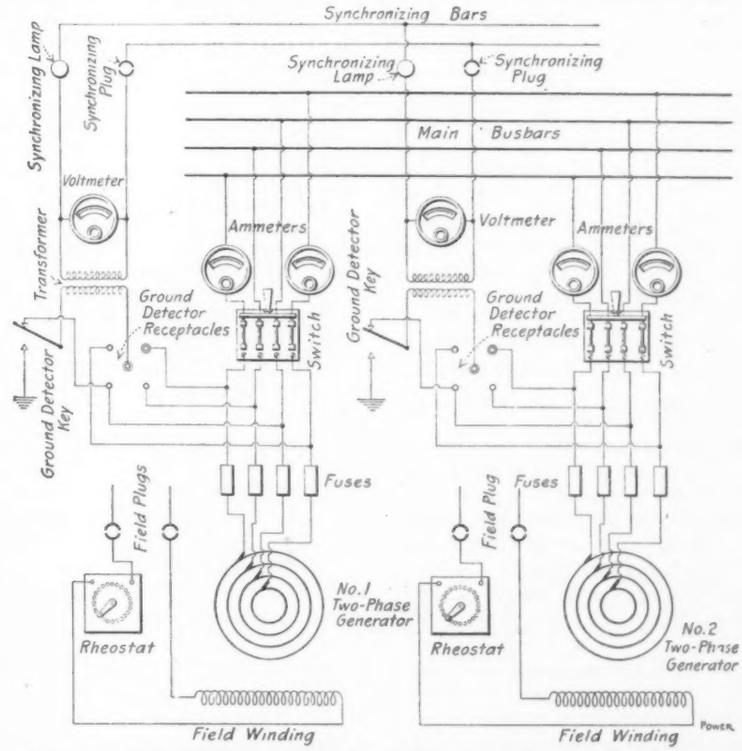


Fig. 4. Switchboard Connections of Two Two-phase High-tension Alternators Operated in Parallel

change from that of exact coincidence to that of exact opposition, the flow of current through the lamps varies from minimum to maximum. If the electromotive forces of the two machines are exactly equal and in phase they will oppose each other and no current will pass through the lamps; if there is any appreciable difference of phase the lamps will light up and the greater the phase difference the brighter will be the lamps. The maximum brilliancy is reached when the phases are in exact opposition. If the machines are running at different speeds they will come into phase and go apart again; this will be indicated by the lighting and extinguishing of the lamps. The rate of pulsation of this lighting and going out depends upon the difference between the speeds of the machines; by adjustment of the engine governors the rate can generally be reduced to as low as one pulsation in ten seconds, which affords ample time for closing the switch connecting the generators in parallel.

When the electromotive forces of two alternators are precisely in opposition to each other—in exact agreement at the busbars—the machines are said to be "in phase," "in step," or "in synchronism." The apparatus used for determining when alternators are in phase is called a "synchronizer."

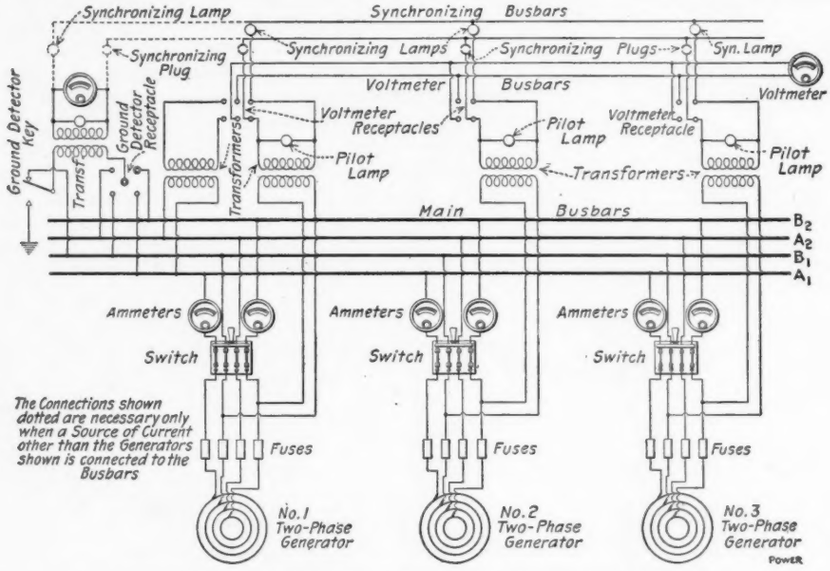


FIG. 5. SWITCHBOARD CONNECTIONS OF THREE TWO-PHASE HIGH-TENSION ALTERNATORS OPERATED IN PARALLEL

STARTING UP AND SHUTTING DOWN

To start an alternator which is to operate in parallel with other alternators it should be brought up to the proper speed in the same manner as a machine which operates alone. The e.m.f. should then be adjusted to equality with the e.m.f. at the busbars, which is that of the generators with which the newly started machine is to be connected. It should then be synchronized with the working alternators and the main switch closed. The rheostat must then be adjusted to eliminate or minimize cross currents and the governors of the driving engines adjusted to distribute the load between the alternators in parallel according to their respective capacities.

When it is desired to cut out an alternator which is running in parallel with other machines, it is best first to reduce the power of the prime mover until it is just sufficient to drive the alternator without taking any load; the resistance in the field circuit should then be adjusted until the armature current is minimum, after which the main switch should be opened. It is usually sufficient, however, to simply disconnect the machine from the busbars, thereby throwing all the load on the remaining machines without having made any previous adjustment of the load or of the field excitation.

The field circuit of an alternator to be disconnected from the busbars must not be opened until after the main switch has been opened; if the field circuit be opened first, a heavy current will flow between the armatures.

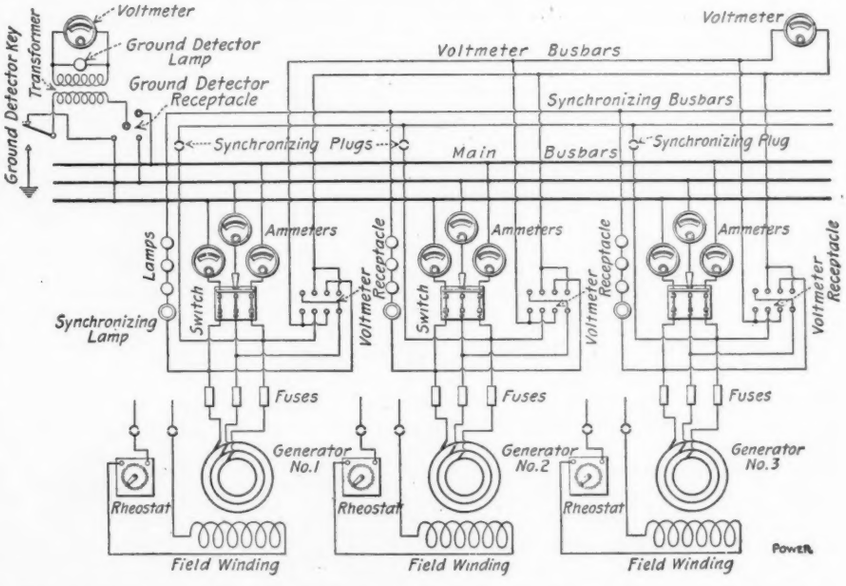


FIG. 6. SWITCHBOARD CONNECTIONS OF LOW-TENSION THREE-PHASE ALTERNATORS OPERATED IN PARALLEL

SWITCHBOARD CONNECTIONS

The method of starting and stopping two-phase and three-phase alternators is practically the same as that for single-phase machines but the connections and switchboard apparatus are more complicated. Fig. 2 shows the connections of two 440-volt alternators connected in parallel. It will be noted that there is a set of busbars for the voltmeter and another set for the synchronizing devices in addition to the main-load busbars; to these latter the ground detector is connected. The hidden lamps connected in series with the synchronizing lamps are necessary on account of the voltage of the machine; each lamp is made to stand 110 volts and four are required in series to stand 440 volts. Suppose, for example, that generator No. 1 is operating and it is desired to start generator No. 2. As with a single-phase machine, it must be brought up to normal speed and voltage. The synchronizing plugs for both machines are then inserted in the receptacles and when synchronism is indicated by the lamps the main switch of alternator No. 2 is closed; then the cross current between the machines is regulated by means of the field rheostats.

Fig. 3 shows the connections for three two-phase machines operating in multiple. They are substantially the same as

those shown in Fig. 2 with the exception of the few modifications necessary where more than two machines are used.

Fig. 4 shows the connections for the parallel operation of two high-voltage two-phase alternators, and Fig. 5 shows the connections of three machines of the same type operating in parallel. The connections are practically the same as those for low-voltage machines with the exception that the switchboard instruments are connected through small transformers to reduce the voltage to a safe value and the generator switches are of the quick-break oil-immersed type.

The connections of three low-voltage three-phase alternators operating in parallel are shown in Fig. 6. The equipment is similar to a two-phase installation with the exception that there are three ammeters to each machine, one for each phase.

The exact connections of alternators will, of course, vary somewhat for different installations, depending upon the special requirements, but they are all based on the same general principles.

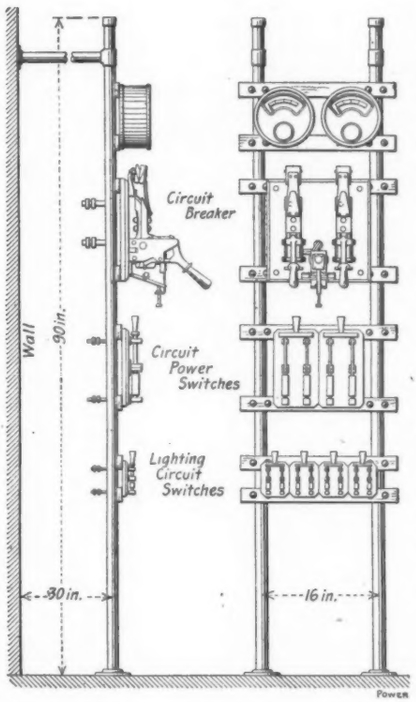
LETTERS

Mr. Crane's Switchboard

In the issue of June 20 there is an article entitled "An Easily Built Switchboard." The board described therein merits the name given to it, as it can be made easily and cheaply. It is not, however, the type of switchboard that should be used for permanent work if any other could be obtained. It very closely resembles the switchboards that were installed about twenty or thirty years ago, when electrical work was just beginning. Since that time practically all of the old boards have been superseded by others of which the switches, circuit-breakers, instruments, etc., are mounted upon slate or marble panels. The reason for this is because of the much greater safety from fire. Although skeleton boards of the type described by Mr. Crane are permitted by the fire underwriters, they are not recommended and the rules require that the wood not only be hard, as stipulated by Mr. Crane, but that it be filled, which he omitted to state and which omission would prevent obtaining an underwriters' certificate if noticed by the inspector.

I also take exception to the statement that such a wooden board can be painted and made to look much better than a slate one, at least after six months of use. With good care, a slate board should retain its polish and good appearance indefinitely, and by "good care" I mean nothing more than the ordinary care that a careful and neat man would give to such a board.

A statement which I either do not understand or cannot believe, if my understanding is correct, is the one in the last paragraph to the effect that in one installation the entire cost of four motors totaling 50 horsepower, with a skeleton switchboard and instruments, was the same as would have been the cost of the switchboard alone if slate had been used instead of wood. I should understand by this statement that all that there was to cause the difference in price was the slate, and it would seem very strange if the slate upon which the control apparatus of the motors was to be mounted should cost as much as the motors. New motors of the sizes given would cost at least $10 and probably $15 per horsepower, or from $500 to $750 in all. They could be easily controlled from panels of the same size as shown in Mr.



AN EASILY BUILT SWITCHBOARD

Crane's illustration or, if necessary, of smaller size. Four such panels would need but little more than 25 square feet of slate; therefore, if the figures just quoted are nearly right, about $20 or $30 per square foot would be the price for the slate. This would seem to be impossible, so that there must have been something omitted that is needed to clear up the statement.

As shown in the illustration, the circuit-breakers are placed immediately under the instruments and very close to them. It would be preferable to place the circuit-breakers at the top of the board where there would be no danger of an arc from one of them, when it opened, scorching anything else on the board. Circuit-breakers are generally located at the top for this reason and the resetting of them from the floor can be easily done if the board is no higher than that shown.

G. H. MCKELWAY.

Brooklyn, N. Y.

Mr. Crane's "easily built" switchboard appears to me to be applicable principally to jobs requiring portability, such as those done by contractors' plants using electric power. This arrangement will allow one to add more circuits or apparatus readily and cheaply and at the same time in such a manner as to keep fire hazards down to a minimum.

The cost of this type of board, however, is very nearly the same as that of a slate panel mounted on a pipe frame. The frame will be the same for either type of construction; the crossbars (which should be of treated wood) and clamps and separate bases for the switches and circuit-breakers will practically equal if not exceed the cost of a suitable slate panel. The cost for labor and material for connecting the various pieces of apparatus will be the same if the work is done as it should be and is up to the usual standard.

In regard to the location of the apparatus, the underwriters suggest that all carbon-break circuit-breakers be mounted at the tops of panels, so that there will be sufficient free space for the arc to dissipate its heat. The arc on a short-circuit, even at low voltage, when the generator capacity feeding into the short-circuit is large, is apt to cause considerable damage unless located so that it cannot reach metallic parts. If the tip of a circuit-breaker is low enough, moreover, it is very liable to burn the operator should he be close enough to the board when the circuit-breaker opens.

Mr. Crane claims cheapness as the principal advantage, but very few people would care to effect the small saving in cost by allowing such a conspicuous sacrifice in appearance.

A. L. HARVEY.

Pittsburg, Penn.

A friend of ours was lamenting the other day that after several years of hard and continuous work one of his boilers had had to be scrapped. He did not mind so much that a new boiler had to be purchased; but he did object to its purchase being forced upon him without a moment's warning. For the end came very suddenly, after all. He had known that it was probable that the insurance companies would have refused to insure the boiler unless the working steam pressure were reduced; but he had not anticipated that the testing hammer of the inspector would have been driven clean through a wasted plate and put the boiler out of the running from that moment. —*Ex.*

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Attachment for Running on Low Grade Distillates

The accompanying engravings illustrate an ingenious attachment which the St. Marys (Ohio) Machine Company applies

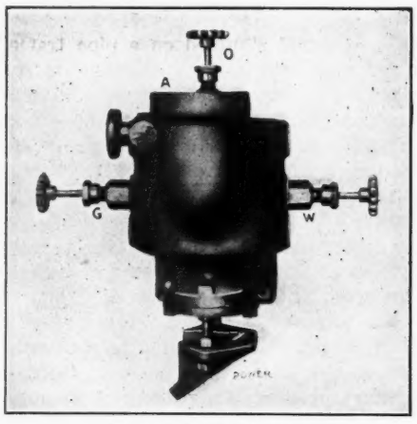


FIG. 1. FUEL FEEDER

to its engines to enable them to run on kerosene, any of the lower-grade petroleum distillates, or gas oil. The attachment comprises a cast-iron fuel-feed chamber provided with three atomizing nozzles, a diaphragm valve and a buffer plate which is adjusted by the governor to limit the play of the diaphragm valve. Fig. 1 shows the fuel-feed chamber, ready to bolt on to the engine over its

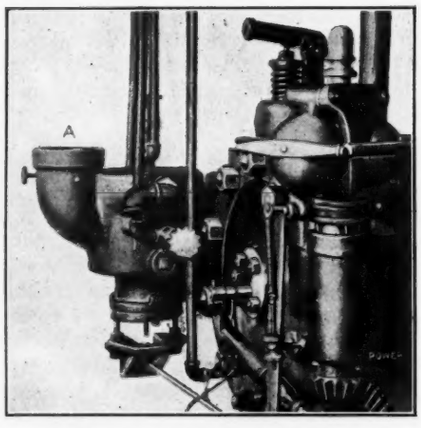


FIG. 2. DEVICE IN POSITION

intake; Fig. 2 shows it in place on the engine, and Fig. 3 shows a sectional view and the linkage between the governor and the buffer plate *B*. The left-hand nozzle *G* in Figs. 1 and 3 delivers gasolene for starting purposes only; the right-hand nozzle *W* delivers water and the top nozzle *O* delivers the petroleum distillate. The air intake is at *A*. After starting on gasolene, with the other two nozzles closed, when the chamber has become warm, the oil valve is opened slightly and the gasolene valve partly closed; a few minutes later, the oil valve is opened wide and the gasolene valve is entirely closed, leaving the engine running on the oil alone.

After changing over to the oil fuel, the water valve is opened slightly, admitting a fine spray which mixes with the fuel and prevents high explosion pressures;

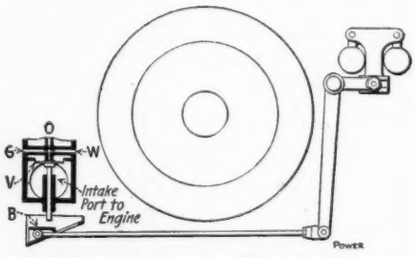


FIG. 3. GOVERNOR CONNECTION

the water is evaporated into steam, which, of course, adds a little to the force exerted on the piston during the expansion stroke.

The fuel-feed chamber is water-jacketed, receiving its supply of water from the outlet of the valve-chest jacket, which is at a higher temperature than the main jacket; this keeps it warm and facilitates the vaporization of the fuel.

The speed is regulated by the adjustment of the buffer plate *B*, Fig. 3; the plate is mounted on two rollers which travel on the inclined plane shown; as the governor balls fly outward, in response to an increase in speed, the plate is pulled to the right and the travel of the rollers up the incline raises the plate to a higher level where it stops the downward movement of the valve stem sooner and thereby reduces the opening of the valve *V*. The valve is drawn downward by the suction of the engine and it is arranged to vary the delivery of oil in proportion to the quantity of air passed by the diaphragm. The engine therefore works with a practically constant quality of mixture.

Constant Quality, Not Constant Compression, Preferred

At the Pittsburg meeting of the American Society of Mechanical Engineers, a written communication presented by Mr. A. E. Maccoun, of which we published an abstract on pages 17 and 18, July 11, contained the statement that the Edgar Thomson Works had found the constant-compression method of regulation better for all load conditions than the constant-quality method. Mr. Maccoun informs us that this was an error (presumably stenographic); his experience has been just the reverse, the constant-quality system being more satisfactory.

Operating Costs of Gas Power Plants

The Plant Operations Committee of the Gas Power Section of the American Society of Mechanical Engineers presented at the Pittsburg meeting of the society a report giving operating costs from four gas-power plants, the names and locations of which were withheld by request of the plant owners. For the purpose of identification the plants were referred to by letters of the alphabet. The essential features of the reports are given herewith.

PLANT "A"

Two pressure producers with generators 7 feet in inside diameter, wet scrubbers 7½ feet inside diameter and 18 feet high and dry scrubbers 7 feet square by 3½ feet high. The producers use bituminous coal, costing $2.55 per ton; two tar extractors are operated.

One double-acting single-tandem engine with cylinders 23½x33 inches. The shaft runs in three bearings and is directly coupled to an electric generator. Speed, 150 revolutions per minute.

The plant runs continuously from 6 o'clock Monday morning until midnight Saturday, every week, supplying electricity for light and power.

The report covers two months' operation, during which a total of 308,410 kilowatt-hours of energy were converted; of this, 35,190 kilowatt-hours were used in the plant and 273,220 kilowatt-hours delivered. The cooling water for the engine is used for other purposes after leaving the jackets and it is therefore not charged to the operation of the plant. The scrubber water was not reported.

OPERATING COSTS PER KILOWATT-HOUR DELIVERED

	Cent
Fuel	0.2576
Producer-room labor	0.1585
Oil	0.0141
Waste, etc.	0.0024
Engine-room labor	0.0555
Producer repairs	0.0127
Engine repairs	0.0040
Total cost	0.5048

PLANT "B"

One set of Loomis-Pettibone downdraft producers supplying one 500-horsepower engine of the same size and type as in plant "A."

The plant operates 10 hours a day and the figures apply to a period of 15 months. Coal costs $4.53 per ton at the plant..

OPERATING COSTS PER KILOWATT-HOUR

	Cent
Fuel	0.4460
Water	0.0879
Oil	0.0465
Waste, etc.	0.0335
Producer-room labor	0.1603
Engine-room labor	0.2050
Producer repairs	0.0243
Engine repairs	0.2375
Total cost	1.2410

PLANT "C"

Two sets of Loomis-Pettibone producers, each of 2000 horsepower rating. Two twin-tandem engines with cylinders 32x42 inches, rated at 1500 horsepower each. Each engine has two main bearings and drives an electric generator at 107 revolutions per minute. Make-and-break ignition.

OPERATING COSTS PER KILOWATT-HOUR IN 1910

	Cent
Fuel	0.422
Water	0.003
Oil and waste	0.024
Miscellaneous supplies	0.015
Superintendence	0.026
Producer-room labor	0.102
Engine-room labor	0.063
Producer repairs	0.024
Engine repairs	0.004
Electrical repairs	0.005
Total cost	0.688

PLANT "D"

Two 400-horsepower producers with generators 8 feet inside diameter, wet scrubbers 8 feet diameter by 20 feet high and dry scrubbers 6 feet square by 3½ feet high.

Three 250-horsepower vertical engines each having three single-acting cylinders 20x19 inches. Each main shaft has five bearings and is coupled to an electric generator. Speed, 230 revolutions per minute. Make-and-break ignition.

The report covers three months' operation. The total running time was 1439 hours and the total output 309,300 kilowatt-hours.

The fuel is No. 1 buckwheat anthracite, costing $2.33 per ton.

OPERATING COSTS PER KILOWATT-HOUR

	Cent
Fuel	0.2828
Oil, waste, etc.	0.0572
Producer-room labor	0.1135
Engine-room labor	0.2640
Producer repairs	0.0249
Engine repairs	0.1496
Total cost	0.8920

CORRESPONDENCE

Mr. Rushmore's Operating Costs

I notice in the June 27 issue a criticism by Mr. De Wolf of Mr. Rushmore's operating costs, in which the item of profit ratio is brought in, the statement being made that a plant owner could hardly consider investing $25,000 in *any branch* of his business unless he expected to make some profit on the investment.

I can understand that a man would not consider going into business unless he expected to make a profit out of it, but I hardly feel that he would go through his plant and pick out the different machines or branches of the business which were most productive of profit, and devote all his money to these branches, unless they were distinct and separate departments, not interdependent details of his general business. A manufacturer naturally has many departments in operation, and none of these departments can be left out. In some particular department I can conceive of the cost being very excessive, so that the ratio of profit might be exceedingly small—in fact, it might be that this particular department, taken as a separate manufacturing process, might show a loss while in some other department the profit might be very great. This would not justify the manufacturer in throwing out that department where his cost was great and increasing that department where his cost was small, as he would then have an unbalanced factory and the results would not be satisfactory. The manufacturer in making up his selling sheets takes into account the sum of the costs in the different departments, the cost of his selling, the overhead charges and such other items as experience has indicated are necessary to be taken into account, and adds to these a fair profit, thus making his selling price. If his power plant is a necessary part of his manufacturing, he considers this in working up his cost data and he would hardly deem it necessary to go through each department and figure out that he must make a certain definite profit in every department, as the salesmen of the lighting companies insist he should.

Take, for instance, the heating plant in a factory purchasing power. Purely as an investment, the heating plant offers no return to the manufacturer which can be termed profit. It certainly is a good investment, however, because it enables his operatives to do their work. Can the manufacturer take his selling organization and go through this and carefully examine into whether it returns a profit on the investment? In many cases he could not get along without it. It certainly has to be taken into account in making up his charges, but he can hardly consider that he must make the same proportional return on money spent in this department that he might out of some other department where the goods are manufactured. Must a manufacturer consider that he should make a profit-ratio return on the cost of his building or the cost of his transmission apparatus? If so, would he not rent it rather than own it, and would he go to the expense of elaborate buildings?

I should like to ask the sales agents to justify their scheme that profit ratio should be considered when figuring up what it costs to produce power in a manufacturing plant.

HENRY D. JACKSON.

Boston, Mass.

[Mr. Jackson's argument is just a little out of line in one or two particulars. His contention that a manufacturing profit should not be added to the cost of operating one's power plant in comparing it with the price of purchased power is quite sound. The object of the comparison is to get at actual relative costs, unconfused with questions of the hypothetical earning value of the money invested. But his argument that the cost of production in a manufacturing establishment should not be considered separately in departments or branches and that an excessively expensive department should not be dropped is an economic fallacy. Many builders of gas engines, for example, buy crank-shaft forgings because they can do so for less money than they could make the forgings.

The weak point in including a manufacturing profit in the items of power-plant operating cost lies in the assumption that the manufacturer could certainly make the money earn that profit if he invested it in some other department of his business instead of in the power plant. No such certainty exists. The current rate of interest is the only charge that should be made against plant investment; that should be made because the money could positively be made to earn it outside of manufacturing considerations. Of course, depreciation, taxes, insurance, etc., must be charged, but these are charges against the equipment, not against the money used to buy it.

Mr. Rushmore's letter contained one point which has not been noticed by any of our contributors, namely, that when an isolated plant is once installed, the interest on the investment goes on just the same if the plant should be shut down and central-station service substituted. Therefore, in considering the use of central-station service instead of an isolated plant that is already installed, interest on such part of the investment as is not redeemable should be charged as an item in the cost of the central-station service.—EDITOR.]

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Locating Keyway in Corliss Valve Stems

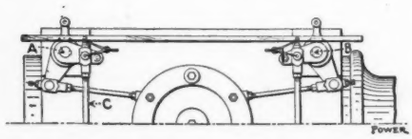
When putting a new valve stem in a Corliss engine it is easy to make a mistake in laying out the keyway, and unless it is accurately located it will be impossible to get the correct lap on the valve without bringing the hook block either too high or too low. If the keyway is cut to bring the block too high with the proper lap, the port opening will be reduced from having to shorten the reach rod from the wristplate to the bell-crank lever; on the other hand, if the block is brought too low, it will be impossible to extend this rod enough to bring the hook so as to engage with the block at the point where it should hook up.

After the new stem is placed in position, the lever *A* (see illustration) can be slipped on over the end of the stem in the place in which it is to be keyed. Then place the lever *A* where it belongs. If the length of the dashpot rod *C* has not been changed from its correct adjustment it will only be necessary to connect it to the lever to bring it to the proper position. If it has been changed a straight-edge can be placed across the hubs of the two levers as shown, using a pair of dividers to measure the distance from the center of the pivot in the end of the lever *B* on the crank end to the bottom of the straight-edge. The dashpot rod *C* on the head end is adjusted to bring the center of the pivot to the end of the lever *A* the same distance from the bottom of the straight-edge. This will bring the angle of the lever *A* right, providing that *B* is correctly placed; if there is any doubt it can be checked by removing the bonnet from the end of its valve and seeing that the lap is correct with the valve hooked up and the wristplate in its central position.

The proper amount of lap to be given the steam valves with the wristplate centrally located is, with a 12-inch cylinder, ¼-inch lap; 14- and 16-inch cylinders, $\frac{5}{16}$ inch; 18-, 20- and 22-inch cylinders, ⅜ inch; 24-, 26- and 28-inch, $\frac{7}{16}$ inch, and 30-, 32-, 34- and 36-inch cylinders, ½ inch lap.

After the lever *B* has been properly placed, hook it up and set the wristplate in its central position. Then the valve is put in its seat and turned until the correct lap is shown for that particular size of cylinder. The keyway can then be marked on the stem and any slight inaccuracy can be overcome by adjusting the reach rod.

In locating the keyway in an exhaust-valve stem, place the new stem in position, and slip it on the lever over the end where it is to be keyed. Next connect up with the wristplate rod and set the wristplate. Then back up the lock nuts on the rod as far as possible and unscrew the rod from the ends until only about two threads are holding. Count the number of threads and screw the rod back half way into its mid-



LOCATION OF KEYWAY IN VALVE STEM

position of adjustment and then set up the lock nuts. Next, place the valve and turn it until it shows an opening corresponding to the amount allowed for that particular size of cylinder. The correct amount of opening to be given for the different diameters of cylinders is as follows: 12-, 14 and 16-inch cylinders, $\frac{1}{32}$ inch; 18-, 20- and 22-inch, $\frac{1}{16}$ inch; 24-, 26- and 28 inch, $\frac{3}{32}$ inch cylinders and 30-, 32-, 34- and 36-inch cylinders, ⅛ inch. With the valve set for the correct opening the keyway can be marked on the stem and then cut out; any final adjustment is made by changing the length of the reach rod from the wristplate.

One should always bear in mind when adjusting the steam valves for lap or the exhaust valves for opening that the wristplate must be in its central position as indicated by the marks on the hub. Many engineers have the mistaken idea that the lap of the steam valves is measured with the dashpots at the bottom. If the correct lap were given with the dashpots in this position it would probably be found impossible to get the engine to pass over its centers on account of the excessive lead.

When a valve stem is broken and the piece containing the keyway is fitted back to be used for a pattern to lay off the position of the keyway in the new stem it is almost certain to be wrong on account of the old stem having been more or less twisted before it broke. This will likely bring the keyway so far out of its correct position that the difference cannot be made up by adjustment. The only remedy will be to either turn the stem over and cut a new keyway on the other side, or widen it and make an offset key. Either remedy makes a bungling job and care should be taken to lay off the correct position in the first place.

S. KIRLIN.

New York City.

Removing a Broken Crank Pin

The intermediate crank pin of a triple-expansion vertical pumping engine is shown in Fig. 1. One end of the pin is forced into the crank *B*, by hydrostatic pressure; the other end is bolted to the block in the crank *A*, which is free to move a little in order to take up any difference in wear of the main bearings.

There are, therefore, two halves, the side *A*, consisting of the flywheel and the high-pressure crank on one-half, and the crank *B*, consisting of a flywheel and the low-pressure crank on the other.

The pin broke as shown, midway between the two crank disks, and was

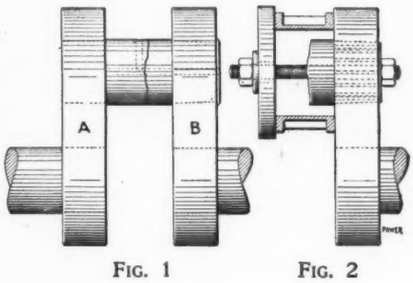


FIG. 1 FIG. 2

covered by the crank boxes; thus the two parts were held together. The break was discovered when the box moved out of the crank *A* and struck the pump rods. The 12-inch crank pin was taken out of the crank *B* as shown and a row of holes was drilled around the outside diameter next to the disk. A large bolt was passed through the core hole and a flanged pipe was put over the pin, as shown at Fig. 2. Then a piece of iron with a hole big enough to receive the

bolts was placed over the pipe and the nut was tightened with a strong wrench and a sledge, while a battering ram was used on the other end of the pin. Of course, the crank disk was heated.

H. R. BLESSING.

Philadelphia, Penn.

Unnecessary Clearance Space

A few years ago, upon taking charge of an 18x36-inch Corliss engine, I found that the cylinder head was put on with heavy gasket tubing, such as is commonly used for manhole covers and other rough work. This held the cylinder head 7/32 inch away from the cylinder.

By replacing the gasket with sheet packing 1/32 inch thick, the clearance space was reduced 47.5 cubic inches.

The use of thick packing nearly doubled the clearance in this case.

ROY W. LYMAN.

Ware, Mass.

Raising a Steel Stack

The accompanying illustrations show the progress made in placing a stack 100 feet high and 5 feet in diameter. The stack was assembled before it was raised and took the place of the two smaller ones shown.

In Fig. 1 the gin poles are in position and the method of guying them and of attaching the blocks and tackle used in hoisting the stack is also shown. The stack is lying in a horizontal position on the blocking ready to be lifted into position.

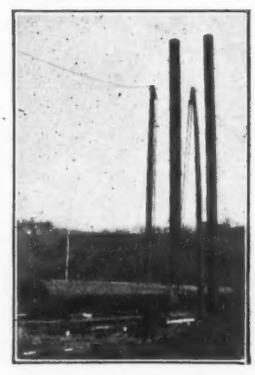


FIG. 1

FIG. 2

FIG. 3

FIG. 4

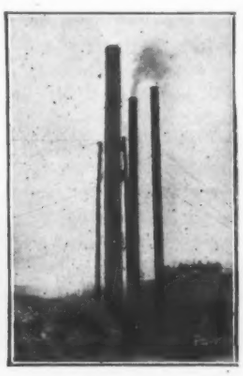


FIG. 5

SHOWING STACK IN VARIOUS POSITIONS WHILE BEING PLACED IN POSITION

The stack is lifted from the ground at one end in Fig. 2, the necessary lifting power being developed by two horses and two windlasses, not shown. The stack is slung nearer to the top than the bottom so that the bottom end will, when the stack has been raised to a sufficient hight, come practically over the brick foundation that has been built for it. Two views of the progress made are shown in Figs. 3 and 4. In the latter view the base of the stack is being swung toward the brick foundation between the two gin poles.

New York, N. Y. R. O. WARREN.

Peculiar Stack Arrangement

Back in 1866 there was built in the northern part of Massachusetts a brick stack, the base of which stands on a hill

BRICK STACK WITH STONE AND TILE SMOKE FLUE

30 feet higher than the grates in the boiler furnace. The boiler house is built at the foot of the hill, and, although the stack has been in service for 45 years and has had several additions built on at the top, it is still in service. The stack is 8 feet square at the base and is 70 feet in hight. It serves two boilers, one of 70 and one of 110 horsepower capacity.

The interesting feature of this old stack is the stone smoke flue, which is partly underground. It is built from small pieces of rock and mortar and forms a flue 24 inches square. The larger boiler is connected to the base of the stack by means of a common tile smoke flue that is 24 inches in diameter. These connections and the stack are shown in the accompanying illustration.

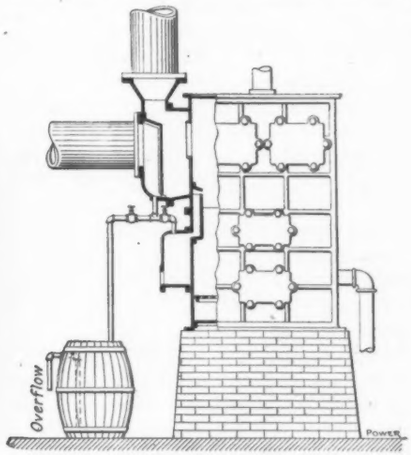
WILLIAM THOMAS.

New York, N. Y.

Saving Cylinder Oil

Many engineers allow the cylinder oil extracted from the exhaust steam of an engine to go to waste.

One engineer devised a scheme to save the oil that passed through his open heater, which was as follows: In the waste pipe that ran to the sewer he inserted a valve beyond a tee connection and connected a drain pipe to an ordinary oil barrel.



METHOD OF REMOVING OIL FROM THE SEPARATOR TO A BARREL

Through one side of the oil barrel, 8 inches from the top, a short length of pipe as placed, having a lock nut on each side of the barrel stave; rubber washers were used to make a tight joint. On the inside of the barrel a pipe extended to within 3 inches of the bottom. On the outside a pipe was connected for an overflow pipe that led to the sewer. The oil that was trapped in the oil separator, together with the condensed steam in it, passed to the barrel. As the oil came to the top it was easily removed and all excess water ran to waste.

In this plant it had required 3 gal-

lons of cylinder oil per day, costing 60 cents per gallon, to lubricate the cylinders of the engines and auxiliaries. After the new system had been put in operation, one gallon of oil was sufficient for all requirements. This made a saving of $438 per year with practically no outlay in first cost or in the operation of the system. The engineer also obtained the purest kind of cylinder oil, which was used to lubricate the auxiliary machinery of the plant.

Brooklyn, N. Y. A. R. BLAKE.

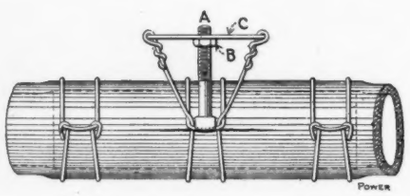
Repairing High Pressure Hose

I was once called upon to do a hurry-up job on a high-pressure water hose which was being used in connection with a water-turbine boiler-tube cleaner with water at 150 pounds pressure per square inch.

The hose had a split about 2 inches in length. I did not want to cut the hose off as it would be hard to hold together under the working pressure. I therefore decided to split the hose to a distance of about 5 inches on each side and then insert a nipple about 10 inches in length, first pushing it into the hose on one side of the split until the other end would enter the hose. Then I centered the pipe in the cut section. This gave me two sides of the hose and kept it from pulling apart.

The next move was to clamp each end to make it water tight. I had no clamps that would fit, so I put on clamps of wire with an instrument I made, its application being shown in the illustration.

When the nut *B* is screwed up on the threads on the bolt *A* it carries the cross arm *C* with it, drawing the wire tightly around the hose. A V-shaped recess is filed on the head end of *A* to receive the bight of the wire, as shown in the illustration.



METHOD OF REPAIRING HOSE

When the wire is drawn tightly enough the tool is pushed forward, thus hooking the two ends over the bight of the wire.

If wire of a high tensile strength is used and a little care is exercised in getting the wires straight, a permanent job is usually the result. A great deal depends, of course, upon the workmanship.

W. DENNIS.

Attleboro, Mass.

Measuring Water without a Meter

The amount of feed water pumped into a boiler is a point of interest to the engineer. If there is a water meter in the pipe line this may be determined, but such an instrument is never correct and a coefficient must be applied. To render the situation more difficult the coefficient varies with the speed of the meter and also with its age.

Assume that a 50-foot pipe line is supplying a boiler with water. The amount of water flowing through the pipe may be determined in the following manner: Tap a ⅛-inch iron pipe into the far end of the supply pipe *A* in Fig. 1. Run this ⅛-inch pipe along the larger one to any convenient point near the boiler or other outlet, and connect it to a U-tube having a scale graduated in inches. Also connect the U-tube to the point *B* in the supply pipe and half fill the U-tube with mercury.

When water is flowing in the supply pipe there will be a drop in pressure between the points *A* and *B*, causing the mercury to be elevated in one leg of the U-tube and depressed in the other. The pressure drop varies with the velocity of flow and it is this fact which makes it possible to determine the volume of water passing through the pipe.

First, however, the arrangement must be calibrated, which means maintaining the difference in pressures constant for a definite period, say 10 minutes, and collecting the water in a barrel and weighing it. For this purpose cut in at some point beyond *B* with a tee as shown. *C* is a three-way valve which is used so that while the desired difference in pressures is being obtained the water may be flowing through one opening of the three-way valve and into the sewer. When the desired pressures are secured the handle of the three-way valve may be turned and the stream discharged into the empty barrel which has previously been weighed. At the end of the 10-minute interval the three-way valve handle is again turned and the stream directed into the sewer. In this way a number of different pressures are taken and the water collected for each. The results should be plotted as in the curve (Fig. 2).

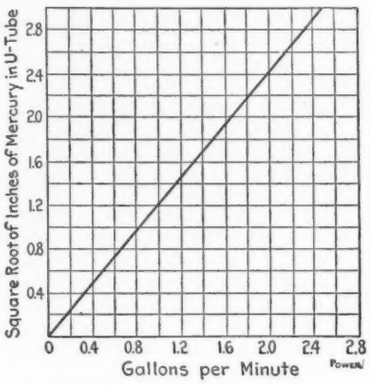


FIG. 2. QUANTITY-PRESSURE CURVE

Such an arrangement is not expensive, but the chief advantage is that when once calibrated it may be depended upon for accuracy at all times. Another feature is that it is not affected by hot or dirty water or chemicals. The distance between *A* and *B* should not be less than 25 feet, but need not necessarily be straight.

A. H. ANDERSON.

Chicago, Ill.

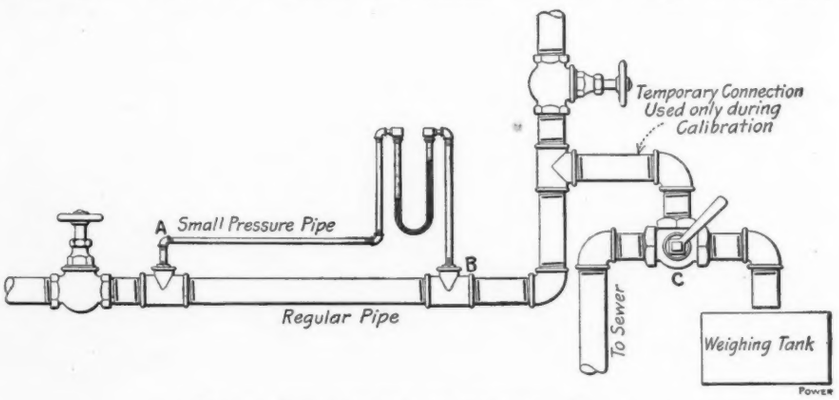


FIG. 1. ARRANGEMENT OF VELOCITY METER

Close Crosshead Clearance

One day a party of engineers visited my plant and my oiler was in high glee because he had a couple of engineers who would listen to him. He was showing them something about the crosshead, and as he was feeling the pin and looking around at the same time, a finger was caught and amputated by the crosshead, which traveled very close to the bored-out part of the frame at one end of the stroke. I afterward measured it and found it only cleared by 1/16 inch at the point where the finger was clipped off. I put up a guard consisting of wire netting fastened with cap screws to prevent a repetition of the accident.

D. L. FAGNAN.

New York City.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

One on the Professor

The method recently described in POWER of how to tell wrought iron from cast iron calls to mind an incident in an experience covering many years in the mechanical-engineering field.

A few years ago while I stood in the machine shop of an institution which teaches the engineering professions, when the professor in charge of the department of mining engineering and metallurgy came in, picked up a round bar of cast iron about 1½ inches diameter and about 12 inches long, from which the molding sand had been cleaned.

He walked over to me and asked: "What kind of steel is this?" Those familiar with cast iron in the rough, as it is called when the sand has been cleaned off and it has not been machined, distinguish it from the other metals by a peculiar coating called "scale." When the casting has been "tumbled" this coating has a shining gray color. When cast iron has been machined it is easily distinguished by its porosity.

To the professor's query I replied: "That is not steel; it is cast iron," and I picked up three other short bars, one each of wrought iron, low-carbon steel and high-carbon or tool steel. He asked me to give him a small piece of all four metals, which I did. He took them away with him.

In a few days he came in again and said the metals were as I had told him. He then remarked that I had picked the bars from a box in which they were all mixed together and asked how it was I could so readily tell each from the other.

I then picked up another piece of cast iron, and with a hammer and chisel began to chip off pieces, at the same time calling his attention to the brittleness of the chips, to the minute porous holes, the "scale" and its peculiar appearance on a casting that had been "tumbled" and on one that had not.

I treated the other metals in the same way, explaining the sand seams in wrought iron and the homogeneous structure of the steels and the coatings of each. He thanked me profusely.

The next day the junior students told me that the professor had very learnedly discussed "the physical properties, characteristic appearance and molecular structure of cast iron, wrought iron and low-carbon and high-carbon steels."

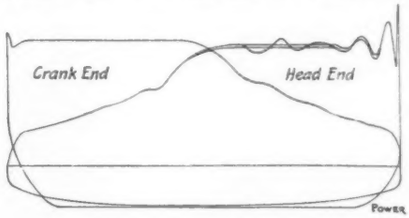
A. P. MANN.

Brooklyn, N. Y.

Indicator Diagram Defects

In a recent issue the accompanying diagrams were offered for discussion. The diagrams were taken from a Porter-Allen engine. The man who submitted them said: "The irregularity of the diagram at the point of admission has puzzled the engineer in charge, particularly as several different indicators have been used on these engines. Why do not the same defects show on both diagrams?"

Being familiar with the Porter-Allen engine I offer the following explanation: When the length of the connecting rod equals six crank lengths, as it does in most of these engines, the difference in the velocity of the piston in opposite ends of the cylinder is considerable, being less at the crank end and greater at the head end. The difference in velocity averages 20 per cent. and between the commencement and termination of the stroke reaches the great amount of 40 per cent.



SHOWING IRREGULAR STEAM LINE OF HEAD-END DIAGRAM

Now the driven arm of the link which gives motion to the valves is also equal in length to six eccentric cranks and its angular vibrations coincide in degree as well as time with those of the connecting rod and so it receives a motion coincident with that of the piston, giving to the valves in opening and closing their ports different velocities, greater at the head end than at the crank end, corresponding to the difference in velocity of the piston.

The serrated steam line of the diagram taken from the head end of the cylinder is caused by the sudden impact of the steam against the piston of the indicator which makes the pencil bar of the instrument vibrate above and below the true steam line.

The reason why the "defects" are not the same on both diagrams is because the admission valve and piston move more slowly at the crank end; consequently there is not such a sudden impulse given to the piston of the indicator as to cause excessive oscillation of the pencil bar before it settles on the true steam line.

I would suggest an increase of compression at the head end to a point a little higher than that shown at the crank end; then a much slower motion will be imparted to the pencil bar of the indicator during more than one-third of its motion; therefore, its momentum would be much less than that produced by the sudden opening of the admission valve when the pencil is bordering on the atmospheric line.

With the above adjustment a higher pressure should be realized at the head end, also a more nearly uniform steam line.

J. W. PARKER.

Clinton, Mass.

Boiler Settings

On page 67 of the July 11 issue, Mr. McGahey says that he has filled the air space provided in his boiler settings for insulation purposes with sand in order to retard the cold-air inflow when cracks develop in the walls. He is quite right in doing this, but the better results in his furnace are not, as he may think, entirely due to stopping up the cracks. While sand will help to stop up the cracks there are other ways of accomplishing this. The principal thing Mr. McGahey did was to retard the heat by radiation, which is far greater than any loss because of cracked boiler settings unless, of course, the settings are in extremely bad condition.

Mr. Dumar, in his article on page 63 of the same issue, states that he packed the air spaces in his boiler settings with asbestos, and has provided as far as possible against loss by radiation.

I would refer all those who are now fighting to hold their jobs against the central station to a bulletin issued by the Bureau of Mines, Department of the Interior at Washington, entitled, "The Flow of Heat through Furnace Walls."

The matter of heat losses by conduction and by radiation is gone into very

thoroughly in this bulletin, which also gives some interesting results of tests and investigations made along this line. The bulletin may be had without charge by applying to the director of the Bureau of Mines.

The conclusions arrived at are that a solid wall is a better heat insulator than one of the same thickness having an air space, particularly if this air space is close to the furnace side of the wall and if the furnace is operated at high temperatures. It is further stated that if it is desirable to build the walls in two parts, to prevent cracks from expansion, etc., the space between them should be filled with such loose material as ashes, sand or crushed brick which will offer a higher resistance to the flow of heat than an air space.

As Mr. Dumar states, too much attention cannot be given to the boiler settings because proper construction means a minimum loss of heat and this again means lower steam costs, all of which is ammunition for the small power-plant engineer to fight with against the central station.

EVERARD BROWN.

Pittsburg, Penn.

Rolling Boiler Tubes

The letter by S. Kirlin in the July 4 issue on the subject of rolling boiler tubes contains several good ideas.

In my estimation there is a proper time to roll boiler tubes, and proper persons should be set to do the rolling. Speaking of tubular boilers, it is my opinion that if the boilermaker, who is really the proper person to do the work, will look over the boiler as soon as the furnace and combustion chamber have become sufficiently cool and before the boiler is emptied, he will get a more intelligent idea of the necessary work to be done and will be able to determine without question just which tubes are leaking and roll them. In tubular boilers with the rows of tubes arranged vertically a tube in one of the top rows only may leak and the water and dirt from it may run down over the lower tubes. To the inexperienced and not thoroughly practical man there will appear to be an immense amount of trouble, especially if the boiler has been emptied. A great many men cannot start rolling at the topmost leaks and work downward, carefully noting the effect of their work. According to my observation it very often happens that many tubes that never have leaked are rolled unnecessarily as a result of this inexperience or the fact that the one who did the rolling did not make note of the work before the boiler was emptied or after it had been washed out and refilled. I am not advocating work on boilers under pressure when I speak of working on them before being emptied.

Men often make the mistake of not having the inner surface of the tube perfectly clean. Others do not have their expander set so that the rolls will not protrude too far into the tube. Others use a too heavy hammer and slam the pin in entirely too hard the first time. It is easy to ruin a tube in just this way if they only knew it. It is very nice if a boilermaker has a correct idea of the thickness of the tube sheet or head upon which he is working in order that he may set his expander collar properly.

Rolling tubes in any kind of boiler should never be done by guesswork. Carefully note your leaks, roll the tubes just enough to stop them and remember to leave enough material to work on in case a leak should occur in the same place at some future time.

THOMAS M. STERLING.

Middlebranch, O.

Massachusetts License Laws and Examiners

When I read articles from time to time advocating the licensing of engineers and firemen in other States, and holding up the present unjust system existing in this State as standard and worthy of all acceptation, I am convinced that the knowledge of this system is very limited. It is my purpose to set forth the conditions as they are found to exist by the applicant for license.

As the law explicitly states that the applicant shall be given a practical examination, let us see what he gets. An applicant for a second-class engineers' license was recently rejected after having taken an examination of which the following questions are typical:

"State the comparative merits of the various makes of steam-engine indicators." This engineer expected to be examined on the practical use of the indicator and the reading and criticism of indicator diagrams, and was prepared to answer the questions, but unfortunately he had never made a study of that phase of the subject and so was considered practically ignorant of this very important instrument.

"Design a double-riveted butt-strap joint for the greatest possible efficiency." An operating engineer with a second-class license who would be called upon in practice to design a boiler joint, or who would be considered an authority on the subject by the average employer, would indeed be a curiosity.

"Design a double-riveted lap joint." All dimensions are given, including the diameter of shell, 60 inches. This is a catch question, the catch being in the diameter of shell, which by law is limited to 36 inches for this style of longitudinal joint.

An applicant for a third-class license was recently given an examination consisting of questions like these:

"What limits the number of stays in the throat of a Heine boiler?" This question properly belongs to the consulting engineer or boiler manufacturer.

"If you were retubing a Babcock & Wilcox boiler, what precaution should be taken regarding the lower tubes?" Who ever heard of a third-class operating engineer, in this State, retubing a boiler? I have worked in eight different plants, some of them large and uptodate, but none of them contained a tube expander. I do not know of any insurance company that will vouch for a job of boiler retubing unless done by a competent boilermaker and there are very few of them even among the best chief engineers.

After an applicant has visited the examiner a sufficient number of times, spent a dollar for each rejection, and has gathered up all the catch and trick questions, he usually gets his license. In the meantime he loses from $12 to $15 in time lost, carfare and incidentals, and has the equivalent of $1; this is the financial injustice of it. The law should read that the examination (?) fee of $1 be refunded if the applicant is rejected. A second-class engineer was asked only two questions at the time of his second visit which he could easily have answered at the time of the first one.

This incident led me to suspect that a clause in the law covering the provision just mentioned might decrease the number of examinations, or even increase the number of licenses granted.

Technical and catch and trick questions and those in advance of the grade of license applied for constitute 50 per cent. of the questions asked. In short, the manner in which deserving applicants are being turned down has the appearance of conspiracy in office against the engineers and firemen. But why? Does the supply of intelligent, capable engineers exceed the demand? The employers claim that engineers and firemen of the right kind are hard to obtain. Have the first-class engineers of the State conspired to keep the assistants down because they fear the natural competition for the higher-priced jobs? This looks logical, but even if true, why should the examiners coöperate with them?

These are the questions which the assistant engineers of the State are discussing. The tendency is not to find out what the applicant knows but what he does not know, and to throw him down if possible.

If the examiners' conception of a practical examination is the true interpretation of the law, then a change in the law or its total abolishment is the only hope of advancement for the present assistant engineers. I am personally acquainted with a chief engineer whose practical knowledge of boilers can be judged from the fact that he never did a day's firing in his life, and also an assistant who for

seven years had charge of a second-class plant on a special license. This man's experience as fireman and engineer covers 14 years and he has been rejected several times for a second-class license. If these men were given a practical examination, their positions would be exactly reversed.

When applicants for second- and even for third-class license are asked questions that make their chief engineers gaze dumfounded and exclaim, "We do not know," there is something wrong; when men who have had charge of large power plants for years candidly make the humiliating statement that under the present conditions they could not get a third-class license, there is something wrong. I know that these sentiments are held by men all over the State, so let us hear from them. I hope to see this vitally important matter liberally discussed in the columns of POWER.

While this injustice is practised indivdually, it is nevertheless a common injury; let us make it a common cause and do something to better the conditions. We should organize and make a common appeal to the legislature through our representatives. We help pay their salaries, but how many bills are they called upon to champion in our interest? I understand that at the last session we had a bouquet handed to us in the shape of house bill 310, and we were just ready to smile, and bow our thanks when we noticed that it deprived us of our right to appeal, so you see there was a trick in it. Just so long as this system of examinations holds sway, incidents like the Pittsfield disaster will continue to shock the public and the practical engineer will remain the assistant.

J. A. LEVY.

Greenfield, Mass.

Alton Boiler Explosion

Referring to the boiler explosion described in the June 27 issue, I agree with Mr. Rockwell as to the cause. I had a similar case myself. My four boilers were of the same dimensions as his, carrying 125 pounds gage, were connected in the same manner to a 14-inch header, and the accident also occurred at 6 a.m. In my case the assistant engineer and fireman came on watch at 5:45 a.m. The assistant's duties were to blow down each water column and see whether there was sufficient water, and then to get the engines ready.

On this morning I got a telephone call at 6:15 a.m. that No. 6 boiler had exploded. On examination I found the fire sheet down from the flange to the girth seam across the whole width of the boiler. This bag was split for about 14 inches at its lowest point lengthwise of the boiler. My reasons for thinking that there was no water in the boiler are that the explosion occurred within 15 minutes after making up the fire. The brickwork of the furnace was not damaged, the grate was not disturbed and some of the green coal fired remained on the wings. The tubes had been rolled three days before the boiler was washed out, under my own supervision, but the insurance inspector gave it as his opinion that scale caused the explosion and his word was taken in preference to my proof to the contrary.

Comparing the two explosions, while a lot of other damage was done in Mr. Rockwell's plant, in mine nothing outside of the boiler itself was injured. There is a wide difference in the result of both explosions. I think this goes to show that conditions must have differed widely at the time as the slight damage done in my case goes, with the burnt appearance of the shell, to show that there was no water. In Mr. Rockwell's case the amount of damage shows very clearly that there was water in the boiler.

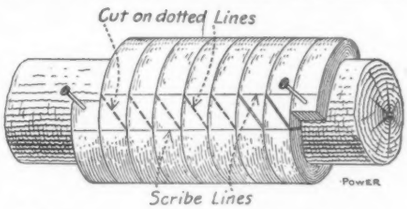
WILLIAM CHADDICK.

Chicago, Ill.

Cutting Packing over Wooden Mandrel

In the issue of June 27, there is a communication from William L. Keil concerning the cutting of packing on a wooden mandrel. The following hints may be of practical assistance to some engineers in this connection:

As a rule, the space between the ends of the ring should be about ⅛ inch for every inch diameter of rod. Using that as a basis, the following sizes of wooden mandrel about which to coil packing for various sizes of rod will be suitable:



PACKING NAILED ON MANDREL AND SCRIBED FOR CUTTING

Diameter of Rod	Diameter of Mandrel
¼	⅛
⅜	¼
½	⅜
⅝	½
¾	⅝
⅞	¾
1	⅞
1⅛	1
1¼	1⅛
1⅜	1¼
1½	1⅜
1⅝	1½
1¾	1⅝
1⅞	1¾
2	1⅞
2¼	2
2½	2¼
2¾	2½
3	2¾
3¼	3
3½	3¼
3¾	3½
4	3¾

Take the coil of packing and nail one end on the mandrel. Spiral the packing tightly and then nail the other end. Scribe two lines parallel to the axes of the mandrel and about 1¼ times the thickness of the packing apart. By cutting obliquely between these marks as scribed, the packing will be cut into rings which are scarfed and which will have just about the right allowance for endwise expansion.

By following these instructions an engineer can cut his own rings accurately and save the extra expense involved in buying rings already cut. Before the rings are inserted they should be dipped in cylinder oil and placed in position so that the open spaces are staggered and do not fall one on top of the other.

W. E. SANDERS.

Trenton, N. J.

Poor Draft

After studying L. P. Cotton's troubles because of poor draft, as described in POWER of July 4, I do not approve of the stack being placed off at one side. As it is, boiler No. 1 should have the strongest draft according to the design of the header and the chimney. A design of this type often causes trouble in maintaining the proper combustion under Nos. 2 and 3. If the stack were closest to No. 2 I believe Mr. Cotton would have no further trouble.

My advice to Mr. Cotton is not to carry a thick fire; make it light and fire often.

WILLIAM T. HURD.

Bellefontaine, O.

Isolated Plant versus Central Station

Much of what Mr. Brown says in the June 20 issue of the *Isolated Plant* is quite true. I differ, however, with his assertions regarding the effect which the various articles in POWER may produce. It is my opinion that the full discussion of this matter in the columns of POWER will serve to save many a plant in which the engineer has been asleep.

Not long ago I went into a plant where the engineer is not much of a reader. His apparatus was doing good work and no doubt he was producing power cheaply. But—some day the central-station man will be around and offer to sell his concern power for 6 cents, perhaps, and it will take this engineer six weeks or more to find out that he is producing it for 3 cents. In the meantime the central-station man is getting acquainted and may be actually putting his offer through.

Mr. Brown brought out a good point when he referred to the willingness of many owners to spend large sums for a good equipment for using outside power while had they been asked to spend a reasonable amount on the private plant to increase its efficiency they would have refused with emphasis.

C. R. MCGAHEY.

Baltimore, Md.

Friction Load Diagrams

The friction-load diagrams of an 8x10-inch Ames engine taken by Mr. Smallwood and shown in the June 25 issue are readily explained by the construction and action of the governor. Fig. 1, herewith, shows in diagrammatic form the positions of the governor parts at head- and crank-end centers, also at the points of greatest and least valve travel. The points *P* and *P'* are the governor-pin positions at the head- and crank-end centers respectively; *e* and *e'* are the eccentric-pin positions at greatest and *l* and *l'* at least travel. The points *R* and *R'* mark the rocker-arm pin positions. The eccentric pin moves along the arcs *a* and *a'* when the governor is being opened and closed and the eccentric-rod head swings through the arcs *A* and *A'*.

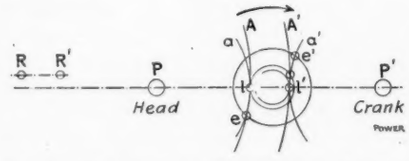


FIG. 1. DIAGRAM OF VALVE-GEAR ACTION

It will be noted that the deviation between the arcs *A* and *a'* is considerably greater at the crank end than at the head end and where the valve is set to have even lead on both centers while the governor pin is in the position of greatest travel, it must have considerably less lead or more lap on the crank end when it is on or near the point of least travel and the engine will give an uneven friction-load diagram as in Mr. Smallwood's case.

I do not know the governor and valve dimensions of an 8x10-inch Ames engine but remember those of an 18x18-inch,

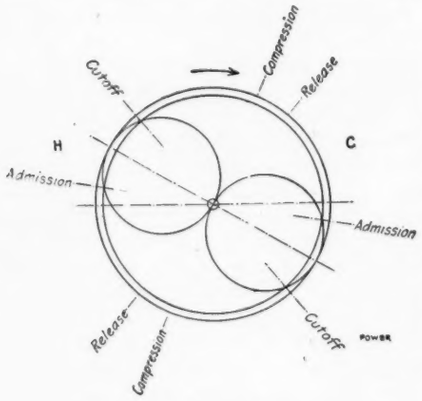


FIG. 2. ZEUNER DIAGRAM

and assuming them to be proportionate will substitute them as they fit the case. The valve has 4 inches of steam lap, ¼ inch of exhaust lap, 5¾ inches greatest and 3 15/16 inches least travel. Supposing that under friction load the governor pin takes the position in the middle circle, Fig. 1, it will be 30 degrees behind the crank, or have 150 degrees in advance as the motion is reversed by the swivel arm, and the valve will have 4¼

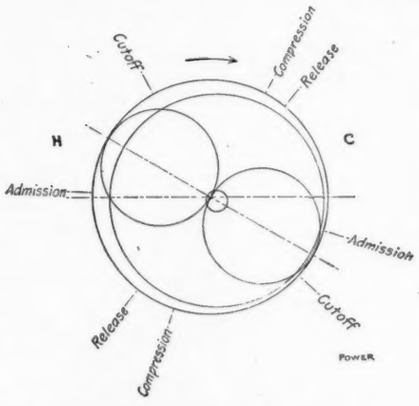


FIG. 3. ZEUNER DIAGRAM APPLIED

inches of travel. The Zeuner valve diagram, Fig. 2, drawn for this motion of the valve, gives the events, provided the valve is set to have even lead at this position of the governor pin. It is not, however, and the lap circles will have to be moved a proportionate distance toward the crank end (about 5/64 inch on a full-size diagram) with the result that there is hardly any admission, later compression and earlier release on the crank end, while there is more steam, early

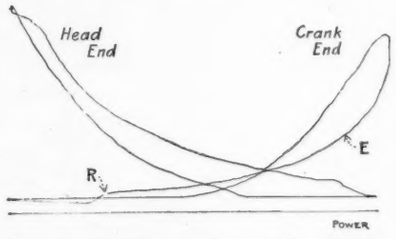


FIG. 4. REPRODUCTION OF MR. SMALLWOOD'S FRICTION-LOAD DIAGRAMS

compression and later release on the head end, as in Mr. Smallwood's diagrams, which are reproduced. The steam line of the crank-end diagram drops vertically because there is no admission while the piston is moving away. The very short term of admission and the reexpansion of the compressed steam keep the line from continuing vertically but cannot prevent its falling below the compression curve. The head-end compression is very early and the engine is using but little steam. The pressure in the exhaust line is therefore low when the crank-end release occurs, as shown by the drop at *R*.

Automatic engines with pivoted eccentrics cannot be adjusted to give even diagrams at all loads. There is always some difference between the full- or no-load diagrams, depending on the design of the governor.

Z. WERNER.

Chicago, Ill.

Cutting Packing

In the June 27 issue, I read with interest, Mr. Keil's method of cutting packing. I have also read every one of "Old Bill's" talks on packing, and some of them several times.

I get the same results in cutting packing another way by making a gage as follows:

Take a piece of dressed pine 1¾x4x27 inches long; on this fasten two strips of the same material dressed to ¾x¾ inch and space ¾ inch apart. After obtaining the length of packing required for a ring, measure this length out on the strips and mark each end with a bevel, putting a stop in on one end; then with a saw cut through the strips to the base.

To cut packing simply lay it in a groove, cut a bevel on the end, push the packing against the stop and then cut it off at the bevel next to you.

I mark the board thus: "Six rings ¾ inch, square flax, for 5x8-inch triplex pump."

My method of packing is: After pulling old packing, cut six rings, graphite three of them, put the first one in with the joint toward me; then one with joint from me or on the other side of plunger. Next, the third one with the joint toward me again. Cut open three rubber rings and break the joints opposite to the flax. When the three rubber rings are in, then put in the other three flax rings. I use a tool to push the rings down into the box. Put the gland down and run the nuts up with the fingers. The packing will leak for a short time but will soon become tight; when it leaks again it is time to repack. I never follow up with other rings or use a wrench. This kind of a job will hold pressures up to 700 pounds per square inch.

J. P. COLTON.

Ohio City, O.

Fitting Gaskets

In a recent number a correspondent describes a case of trouble with rubber gaskets blowing out. In several similar cases I have prick punched one of the surfaces between which the gasket was to be fitted. The gasket material would work into the holes and consequently the gasket would hold better. In each instance this has overcome the trouble very satisfactorily.

When it comes to tightening up bolts, many men are governed not by the strength of the bolt but by the length of the wrench and their own strength. More wrecks are caused by overstrained bolts than by bolts that have not been set tight enough. It is only the real engineer or machinist who can tell by the "feel" when a bolt or nut is properly tightened.

J. O. BENEFIEL.

Anderson, Ind

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POWER

Take no Chances

In the issue of July 4, a correspondent attributed the flywheel explosion in the power station at West Berlin, Mass., to the overspeeding of one of the engines. The engines were run condensing at 88 revolutions per minute and were belted to direct-current generators of about 200 kilowatts capacity. The governor pulleys were not provided with flanges to prevent the governor belt from running off. It was assumed that the explosion may have been caused by the safety device failing to operate.

While the immediate causes of flywheel explosions are various, and often difficult to determine, it is not wide of the mark to assert that either neglect or carelessness is usually the ultimate cause.

To examine the governor gear daily, to make a hammer test of and inspect the flywheel frequently, is the practice of but few engineers. This is good "life and property" assurance.

Few men are willing to take chances in the ordinary walks of life; they regulate their hours of working, eating and sleeping; when the machinery of the body appears to be out of gear it is given a thorough inspection and tested for its efficiency and safety. They are constant in its care and watchful, day in and day out; they cannot afford to take chances.

Wherever there is even a possibility of accident due to weakening of parts or inoperative appliances, the daily vigilance of the engineer is the price of his safety and that of the property committed to his charge. It may be that a daily rigid inspection for years would fail to reveal a crack or break, but no engineer can be confident whether everything is as it should be until he has made a thorough inspection and test.

A reliable report of the flywheel explosions in the United States for the year 1910 states that there were 67 accidents in which 16 men were killed and 28 were injured. The great loss of property, wages and profits cannot be approximated.

It is appalling to think what the loss of life and property might be because of an explosion in a plant in a thickly populated section of a city. In the West Berlin power-plant explosion a piece of rim 7 feet long and weighing nearly a ton was hurled through the roof of the station and landed 400 feet away, and the outboard bearing was torn from its bed and driven through the brick wall of the building. While there was no loss of life in the explosion, there probably would have been had the plant been in a large city.

The figures given in the foregoing report should make the thoughtful and careful engineer sit up and take no chances.

Value of the Hammer Test

Not long ago a locomotive type of boiler carrying one hundred and seventy-five pounds pressure exploded within five weeks from the time it was inspected and guaranteed to be safe for operation at the pressure given. The initial rupture occurred in the firebox, the side of which was torn from some forty of the staybolts, fifteen of which were found to have been broken for some time before the accident.

It is impossible to determine the conditions existing in the narrow space of the water leg of a locomotive boiler and the inspector is obliged to rely upon the meager information furnished by his hammer as it is applied at different points.

Thin spots in a boiler plate may be detected by a skilled inspector with the hammer if there is a serious wasting and loose or broken stays reveal themselves. But when the stages are only cracked the most expert may be deceived if guided by sound alone. It is a comparatively easy matter to drill small test holes in a plate where weakness is suspected, but it is not so simple with a large number of staybolts in position in a firebox. These stays are subject to a bending effect at every change of the temperature of the water, owing to the difference in expansion between the outer and inner sheet which finally breaks the bolt.

For this reason hollow staybolts are becoming more common in the construction of firebox boilers and this explosion emphasizes the desirability of extending the practice.

It is undeniable that the hammer test in places which the eye cannot reach is not conclusive and it should be supplemented by the hydraulic test for boilers of this type.

Steam Plant Design

When we see a steam plant, especially a new steam plant, we conceive the designer studying each element and selecting from those available the type most adapted to the conditions in hand. We put ourselves in the engineer's place and try to determine the scientific considerations which led him to use such and such an element here and there. And sometimes the profundity of the problem is beyond our depth.

As a matter of fact the considerations which lead to the form and character which steam plants take on are usually not to be found in books upon engineering nor to be explained by any of the tenets of the profession.

Few plants are designed by engineers with unrestricted freedom to produce the station which will turn out power at the smallest cost. They are mostly compromises with restricted space, financial limitations, and, worst of all, with the necessity of putting in this or that, or warping the design to allow of the use of thus and so to please a director, a stockholder or a customer. Instances are not wanting where the judgment of the engineer has been warped by the fact that he had an interest in the sale of some of the apparatus. If his agency is acknowledged and open the client accepts the probability of getting his goods if they will work in, but the professional designer should have no underground connections which may influence his decision.

When, therefore, you attempt to analyze a plant and find it difficult to account for, do not dig too deeply for abstruse engineering reasons on the one hand, nor question the good sense of the engineer on the other. If you had been in his place you might have found "the ties that bind" just as aggravating as he did.

Precedent

The average man is a conservative institution. Usually, before he will try something new he wants to know who have done the thing, what success they have had, how much it cost, *et cetera.*

Conservatism seems to be most virulent in the field of engineering. More really idiotic practices than you can readily enumerate endure simply because most men are afraid to attempt to reason for themselves and break away from the precedents established by their forefathers. Salesmen appreciate the truth of this perhaps more than the men of any other class. Ask any man who is trying to sell some device which is based on a new idea or which departs a little from common practice what his opinion is of this human inertia.

What applies to the introduction of new apparatus applies even more extensively to the introduction of new methods. Many a man persists in doing a thing in a certain way for no more satisfactory a reason than that he was "learned to do it that way."

Take, for an example, the matter of furnaces for fire-tube boilers. Few who have studied the subject to any extent will deny that the distance between the grates and the boiler shell should be made much greater than it commonly is made. Also, that this distance should vary with the nature of the fuel and not with the size of the boiler or grates or something else. Yet, very little change has been made in the furnace design the precedent for which was established in the long ago when knowledge of the fundamentals was pilifully small.

When crude oil was first used under steam boilers the ordinary coal grates were partially covered with a course of firebrick and the burners were inserted through holes chipped in the fire doors. Practically no departure from this arrangement is made even today when oil fuel has been in use for years.

Dozens of similar examples could be offered.

This lack of willingness to take the initiative, to break away from the beaten path, retards the progress of the world perhaps more than anyone has ever remotely suspected. And, after all, is it not due mostly to man's inability or unwillingness to reason for himself? Do not the most of us, either by preference or necessity, "let George do it"?

Oil Fuel

In spite of many advantages, such as ease of handling, cleanliness and flexibility of operation, the adoption of oil fuel, except in localities where coal is expensive and oil relatively cheap, is progressing very slowly. This is largely due to its general inability to compete in price with the lower grades of coal which are now being burned successfully, and to the relatively limited supply.

Regarding the latter point, however, since the discovery of the Texas and California oilfields a few years ago the output has been greatly increased. Last year the total production of crude petroleum in the United States was two hundred and sixteen million barrels, much of this, however, being used for industrial purposes. During the same period four hundred and eighty million tons of coal were mined in this country. Considering, on an average, that one ton of coal is equivalent to four barrels of oil, it will be seen that the present production of oil (including that used for industrial purposes) would have to be increased ninefold in order to supplant coal as fuel.

Reference to the figures of the tests with oil fuel (see page 170 of the present issue) which were conducted by the Babcock & Wilcox Company for the Navy Department will show some interesting results. The efficiencies attained were not as high as those reached in the tests at the Redondo plant a few years ago, but in the present case the rate of forcing was much higher.

In test No. 1 the heretofore unheard of evaporation of 15.83 pounds of water per square foot of heating surface was attained. To produce this 13.69 pounds of oil per cubic foot of furnace volume, equivalent to 75.34 pounds of coal per square foot of grate surface per hour, were burned. As might be expected, the flue temperature was unusually high in this case. In spite of this high rate of forcing, the efficiency was not materially decreased, which speaks well for the circulation in the boiler.

In viewing the results of these tests, however, it must be remembered that they were made with a closed fire room, with steam jets in the stack, and were conducted by men long experienced in handling oil fuel—a combination of conditions which would not be met with in ordinary operation, except perhaps in some phases of naval practice. Hence these results, while showing the possibilities of oil fuel, are not typical of average everyday practice.

In speaking of the cause of a recent boiler explosion an ex-inspector said to a reporter. "The crack was on the inside of the outside sheet, and the boiler was so small that a man could not get inside in such a position as to see this crack, even if he were to make an investigation.

"This crack was obscured from sight by an inside lap, and the crack would become deeper and deeper, caused by the vibration. This was sufficient to weaken the boiler and cause it to explode."

It is, of course, needless to say that the exploded boiler was of the lap-seam type and that the size of the boiler had nothing to do with the invisibility of a crack which could be discovered only by unmaking the boiler and opening the seam until inspection was possible.

In deliberating whether to continue the use of the isolated plant or to adopt central-station service, the engineer's earnings outside of his regular duties are usually overlooked. In many plants the engineer is the plumber, the steamfitter, the carpenter and the machinist, and when he is eliminated the odd jobs that fell to him will have to be paid for at the regular rates plus the shop owner's.

According to the United States Geological Survey, nearly 100,000 horsepower is being developed from falling water in Tennessee. The completion of water-power projects now under construction will probably more than double the present development in that State.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Opening Gage Glass Valves

After putting in a new water glass, which valve should be opened first?

O. G. G.

When a new water gage has been put in, open the drip cock at the bottom of the column and open the top cock, admitting steam to the glass slowly and allowing it to heat up before the water connection is open. The glass will in this way be heated more evenly and, if it breaks, the results will be less disastrous than if the water cock were opened first.

Gain from Use of Condenser

Is there any saving in using a condenser, when there is use for the steam elsewhere? What is the gain in using a condenser ordinarily?

H. G. Y.

There is no economy in employing a condenser and sending heat units into the river when they are useful for heating or manufacturing purposes. A steam engine used as a reducing valve between a high- and low-pressure system is the most economical heat engine in existence.

The gain in using a condenser depends upon the initial pressure and the ratio of expansion, as well as upon the type of engine. With a very low initial pressure and an early cutoff the area of the diagram below the atmospheric line will be a large proportion of the whole, while with a high initial pressure and a late cutoff the vacuum area will be a much smaller percentage. The effect of the condenser in carrying the engine toward or away from its maximum efficiency should be considered. The accompanying table from Gebhardt's "Steam Power Plant Engineering" gives the effects produced in some average cases.

EXAMPLES OF THE EFFECT OF CONDENSING ON THE ECONOMY OF RECIPROCATING ENGINES

	Noncondensing			Condensing				Increase Due to Condensing	
Reference Number	Initial Gage Pressure	Horsepower Developed	Steam Consumption, Pounds per H.P.-Hour	Initial Gage Pressure	Back Pressure, Pounds per Square Inch Absolute	Horsepower Developed	Steam Consumption, Pounds per H.P.-Hour	In Power, Per Cent.	In Economy, Per Cent.
1	147	54.7	19.2	149	1.6	83.4	14.8	52.5	25
2	148	540	19.3	147	4	.....	16.9	....	12.5
3	126	83	23.8	130	7.4	116	19.1	39.8	19.7
4	67.6	209	28.9	67	4.5	213	22	1.9	23.5
5	103.8	177.5	22.1	103.8	1.2	155	16.5	....	25.1
6	114	160	31	114	.....	168	27	2	12.9
7	96	120	23.9	96	4	145	19.4	20.8	18.8
8	118	267	23.24	119	4.2	276.9	16	3.7	31
9	75.9	310	25.6	79	6.4	336	20.5	8.7	19.9
10	62.5	451	30.1	63.6	7.8	444	23	....	23.6
11	186.7	40.4	18.7	184.6	1.6	29.8	12.7	....	32

Hight and Pressure of Water

The pressure at the bottom of a standpipe is 95 pounds per square inch; what is the hight of the water?

H. P. W.

A column of water 1 foot in hight at rest will press upon its base with a pressure of 0.433 pound per square inch.

Direction of Compressor Rotation

Is there any particular reason why an air compressor should run under?

D. C. R.

There is none. In fact, the friction will be slightly less when running over.

Equalizer

What is an equalizer as used on a boiler having three lugs on a side and how is it constructed?

H. E. C.

An equalizer is a device which equalizes the distribution of the weight on the three brackets on each side of a boiler. The front ones are usually attached to an overhead girder and the others to a short beam which is suspended at the middle from another girder.

Length of Rivet

How can I tell what length to have rivets so they will fill the rivet holes and form a head equal in strength to the body of rivet? What is the formula for finding the strength of rivet heads?

E. C. H.

The rules depend on the style of head and do not give the exact sizes. For common conical heads the rivet should project through the sheet 1¼ diameters for hand riveting and ⅛ to ¼ inch more for machine work.

Chamfered Rivet Holes

Why are rivet holes chamfered before driving the rivets?

H. D. P.

They are chamfered for the purpose of removing the bur left by the drill or reamer.

Horsepower for Given Cutoff

In a simple noncondensing 12x26-inch engine, cutoff occurs at ⅝ of the stroke. With 100 revolutions per minute and 90 pounds steam pressure, what is the approximate horsepower?

H. G. C.

The mean pressure of expanding steam at ⅝ cutoff is 91.87 per cent. of the initial. Assuming that 90 pounds gage pressure is realized in the cylinder and that the steam is exhausted at 2 pounds pressure above the atmosphere, the mean forward pressure on the piston will be

$$105 \times 0.9187 = 96.46 \textit{ pounds}$$

The mean effective pressure is the mean pressure less the back pressure which in this case is taken at 16.7 pounds absolute.

$$96.46 - 16.7 = 79.77 \textit{ pounds}$$

The horsepower of an engine is expressed by the formula

$$\textit{Horsepower} = \frac{PAS}{33{,}000}$$

in which

P = Mean effective pressure;
A = Area of piston;
S = Speed of piston in feet per minute.

Then

$$\frac{79.77 \times 113 \times 435}{33{,}000} = 118.82 \textit{ horsepower}$$

The actual horsepower developed would, owing to the failure to realize full pressures in the cylinder up to the point of cutoff, wire drawing, etc., probably be about 85 per cent. of the theoretical, or

$$118.82 \times 0.85 = 100.99 \textit{ horsepower}$$

Heating and Ventilation

Considered as power plant problems. Layout and operation of systems and apparatus

Combined Vacuum and Gravity Return Heating System

By Charles A. Fuller

A very interesting combination of vacuum exhaust-steam and gravity-return heating system is found in the New York Trade School, at Sixty-seventh street and First avenue, New York City. The main part of the buildings, including shops, workrooms, classrooms, etc., was originally heated with exhaust steam from the power plant on a gravity-return system. To get proper circulation, however, it was necessary to carry quite an excessive back pressure on the engine, due to the length of lines and small size of piping. The office building was heated by a separate plant, using a low-pressure boiler and gravity-return system. No attempt had been made to operate the two systems in conjunction.

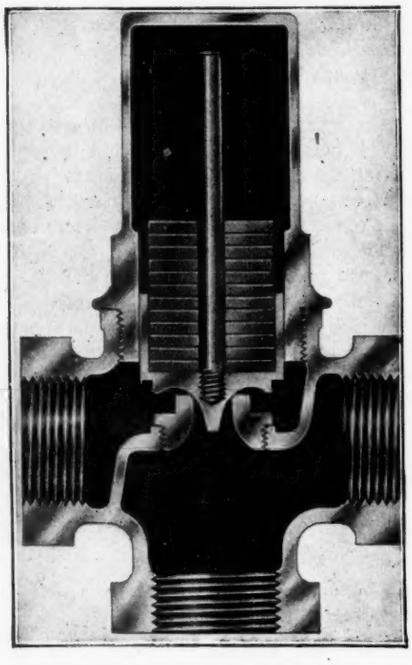


Fig. 1. Weighted Check Valve

The reason for making alterations was to cut down the excessive back pressure on the engine by the use of a vacuum system, and to connect the two systems so that when exhaust steam was available the entire plant, including the office building, could be heated by this means. It was also necessary to arrange the office plant to operate independently as a gravity-return system at such times when exhaust steam could not be had for heating purposes.

The so called vacuum-heating system produces circulation of steam by removing the air and condensation from the coils and radiators with a vacuum pump or other vacuum-producing device. Creating the desired vacuum in the return lines and removing the air from the system allow the exhaust steam from the engine to flow into the heating system at approximately atmospheric pressure. The annoyance of air valves on coils and radiators is also done away with, the air being taken out from the return lines by the pumps.

Small automatic traps of the float, thermostatic or weighted check-valve design, are placed on the return ends of each radiator or coil, which allow the air and condensation to pass but prevent or regulate the passage of steam into the return lines.

In this particular plant weighted check valves were installed in the branch returns in the basement at the points where these returns discharged into the main return line. The return end of each radiator and coil was equipped with a swing check valve having a restricted orifice. The weighted check valves shown in the illustration are provided with means for adjustment by adding or removing weights as may be required. These valves then serve to divide the whole plant into small groups.

The drop in pressure in the supply mains and drop in vacuum in the return mains to any particular group may be compensated for by removing the weights in the valve controlling that particular group; they are removed until the required amount of vacuum to produce proper circulation is obtained. Means are also provided for balancing the swing check valves, thus compensating for any drop in pressure within the group itself. This drop, however, is usually so slight that this precaution is not necessary. The adjustment of the weighted check valves produces practically the same difference in pressure between the supply and return end of each radiator or coil in the entire plant, regardless of its distance from the source of supply.

In the accompanying plan, Fig. 3, the basements of the various buildings are shown. The general arrangement of the supply and return mains is indicated on this plan with the location of the weighted check valves shown in the branch returns. In the office and library

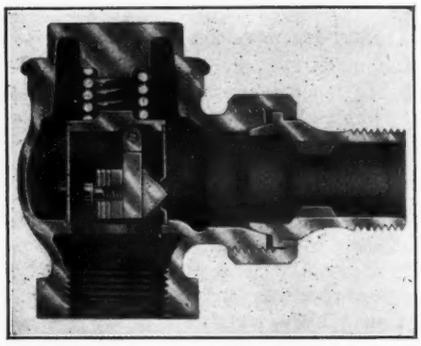


Fig. 2. Swing Check Valve

building is shown the low-pressure boiler used for heating this building when the power plant is not running. A plan and elevation showing the general arrangement of piping is given in Fig. 4, which is drawn to a larger scale.

The steam-supply main from the power plant enters the basement at *F* and joins the steam supply from the low-pressure boiler at *G*. From here the main *M* distributes through the various supply risers to the radiators. The return end of each radiator is equipped with the swing check valve previously described. These returns all connect into the return main *O*. At the point *R* this return branches into two lines, one running as shown through the weighted check valve and thence to the main return line running to the vacuum pump. The other line from *R* drops below the water line and enters the low-pressure boiler through valve *D* in the usual manner. The steam mains are all dripped into the main drip line *P* which enters the main return at the point *K*.

The air valves on all the radiators were removed and the openings plugged. One large thermostatic air valve is connected into the main return above the point where this return drops to the water line of the boiler. This valve serves to remove all the air when the low-pressure boiler is in service. The discharge from

the air valve is equipped with a globe valve which is closed when the building is heated by the vacuum system from the power plant. The drip main is connected into the return main below the water level so that no steam can short-circuit through the drip points to the return.

and into the main return of the larger system. The condensation in the steam mains passes as before into the drip line *P* and back to the point *K*. Here it rises into the return main at *R*. Because of the weighted check valve in the branch return there is a comparatively low difference in pressure between the steam

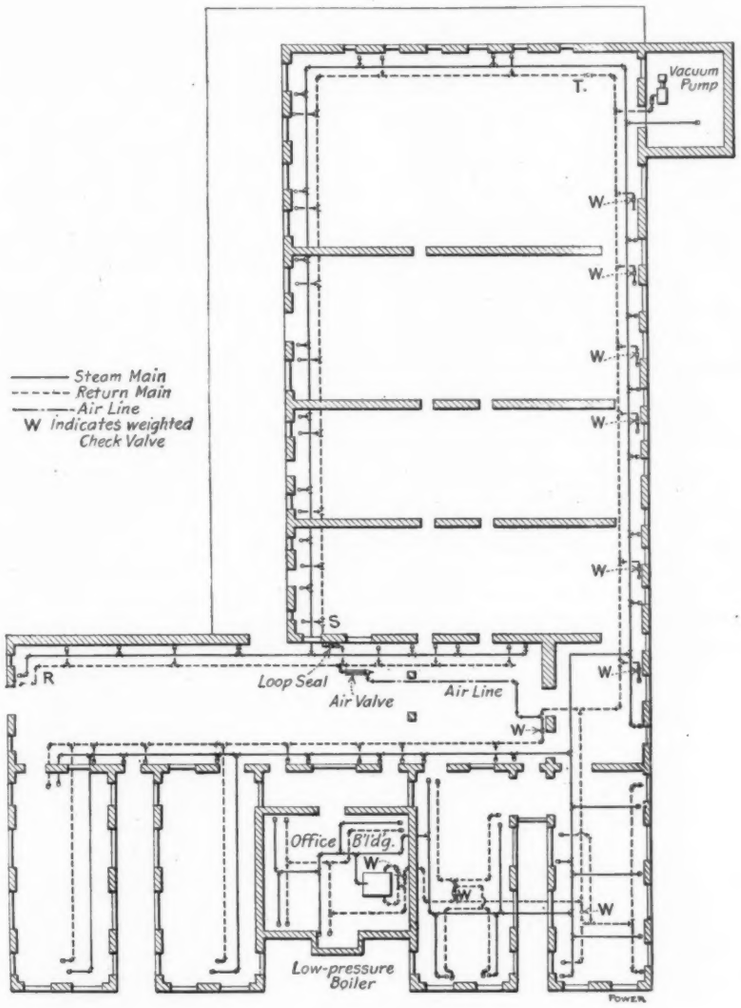


FIG. 3. BASEMENTS OF BUILDINGS

To operate the plant from the low-pressure boiler as a gravity return, valves *B* and *C* are closed, valves *A* and *D* are opened and also the small valve *E* on the discharge from the air valve. The system, then being entirely separated from the main steam and return line, can be operated independently and also interferes in no way with the operation of the main system.

To cut out the boiler and heat the building by the vacuum system, valves *A* and *D* are closed and the valve *E* on the air line is closed to prevent the air from entering into the return mains. Valves *B* and *C* are opened. Steam then enters the line *F* and is distributed in the same manner as before. The air and condensation pass through the return main *N* through the weighted check valve and return pipes which is not sufficient to lift the water out of this seal and cause short-circuiting through the drip line.

It can readily be seen that, as the vacuum-return line is connected at the water line of the boiler, with valves *D* and *A* closed the water level in the boiler can in no way be affected by the action of the vacuum pump, and it is not necessary to adjust this each time the boiler is put into service.

Another interesting feature in connection with this plant will be found in the return line designated by the letters *R*, *S* and *T*, Fig. 3. This return line handles the condensation from practically one-half of the entire plant. From the point *S* back to the power plant this return was laid below the floor and it was impossible to make any alterations in it, or to run a supplementary branch return line to handle the condensation from this portion of the building.

It was therefore possible to install only one weighted check valve in this return line at the point *T* as shown on the plan. This made an extremely large group to be controlled by one weighted check valve, and it was necessary to divide the group by means of introducing what is known as the Paul system, on one portion of the group. At the point *S* the return line was loop sealed as shown in the sketch. This established an independent water line in the return main and separated the group *R*—*S* from the group *S*—*T*. At a point in the branch return above the water line in the loop seal, a large thermostatic air valve was placed and an air line was run from this valve and connected into the high-vacuum compartment of the main return line. (By high-vacuum compartment is meant the part of the return main between the weighted check valve and the vacuum pump.)

It can readily be seen that the air from this portion of the system would then be taken out through the air line and back to the pump through a separate circuit, while the water of condensation would pass through the loop

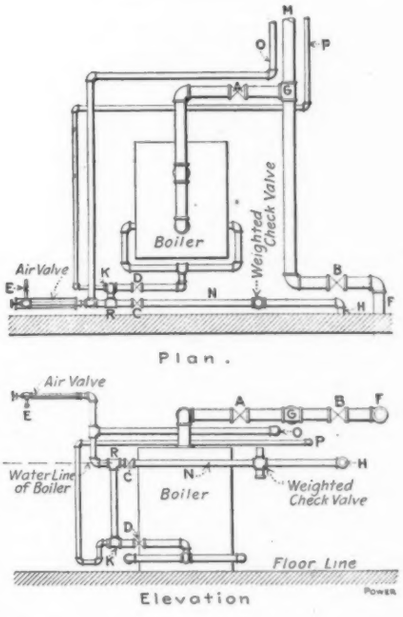


FIG. 4. GENERAL LAYOUT OF PIPING

seal back through the return line *S*—*T* through the weighted check valve and to the pump. The air valve works thermostatically and will close as soon as steam attempts to pass, and, at the same time, when any air collects in the system this valve will open and allow this air to escape into the main return line.

Legislation on Compulsory Ventilation*

The last report received from New York shows the factory-ventilation bill still in the balance. This bill is an amendment to the one passed in 1909 and is a credit to the committee of which D. D. Kimball is chairman. It is hoped that the bill will pass, although there has been some agitation toward the formation of a commission to investigate the entire factory proposition and report back a general bill covering all phases of the factory work. Other than this there seems to be no serious opposition to the bill.

In reading over the present statute and comparing it with the proposed amendment one is impressed with the improvement. The amendment is very definite concerning the quality of the air, whereas the present law is very vague and leaves the matter open to the discretion of the commissioner of labor. Two bases are given for determining the quality of the air, as shown by this quotation from the proposed law:

"A workroom shall be deemed to be provided with sufficient means of ventilation if provided with means of ventilation which will supply constantly in all parts of the room air, either of the quality or in the quantity hereinafter prescribed. A workroom shall be deemed to be properly and sufficiently ventilated if the air in the working parts thereof does not contain more than nine parts of carbon dioxide in 10,000 volumes of air in excess of the number of parts of carbon dioxide in 10,000 volumes of the exterior air, or if there is constantly supplied throughout the interior of the room at least 1200 cubic feet of air per hour for each person therein present and employed, and in addition thereto at least 1000 cubic feet of air per hour for each cubic foot of gas burned per hour, such air to be taken from an uncontaminated source; provided, however, that if gases, fumes, vapors, fibers, dust or other impurities are generated or released in the course of the business carried on therein, the room must be further ventilated by providing at the point of origin of such impurities proper hoods and pipes by and through which such impurities shall be collected and removed, and such pipes and hoods shall be connected to exhaust fans of sufficient capacity and power to remove such impurities and such fans shall be kept running constantly while such impurities are being generated or released."

The question of temperature, which was not mentioned in the present law, is also taken up as follows: "And provided further, that the temperature in any factory workroom, except a boiler room, shall not exceed 72 degrees Fahrenheit, as determined by the wet-bulb thermometer, unless the temperature of the exterior air exceeds 70 degrees Fahrenheit, as determined by the same process, in which case the wet-bulb temperature of the workroom shall not exceed that of the exterior air by more than 5 degrees."

In Massachusetts the committee on compulsory ventilation is having its ups and downs also. Since the last meeting a commission appointed by the governor to investigate the subject presented a bill to the legislature which would provide for an unpaid commission of five members whose duty it would be to appoint a chief commissioner, two deputies, a register and 50 inspectors; 10 of these inspectors are to be women. The unpaid commissioners would have power to fix the term of office, adjust the salaries and discharge and appoint employees. This bill had a large opposition. At last report this bill has been called up for final vote.

The work of the Illinois committee, since the last meeting, has been done in connection with Doctor Evans and the Chicago department of health. A great amount of work has been accomplished but there is still a great deal to do.

Indiana fell into line on March 3 with a ventilation law that is good as a starter. The State committee, with Mr. Weinshank as chairman, working in connection with the Medical Association and Doctor Hurty, the State health officer, succeeded in passing a bill affecting principally the schools of the State. Extracts regarding the heating and the ventilating are as follows:

"The ground floor of all school houses shall be raised at least 3 feet above the ground level, and have, when possible, dry, well lighted basements under the entire building, and shall have a solid foundation of brick, tile, stone or concrete, and the area between the ground and the floor shall be thoroughly ventilated. Each pupil shall be provided with not less than 225 cubic feet of space.

"Cloakrooms, well lighted, warmed and ventilated, or sanitary lockers shall be provided for each study schoolroom.

"Ventilating heating stoves, furnaces and heaters of all kinds, shall be capable of maintaining a temperature of 70 degrees Fahrenheit in zero weather and of maintaining a relative humidity of at least 40 per cent.; and said heaters of all kinds shall take air from outside the building, and after heating introduce it into the schoolroom at a point not less than 5 nor more than 7 feet from the floor, at a minimum rate of 30 cubic feet per minute per pupil, regardless of outside atmospheric conditions; provided, that when direct-indirect steam heating is adopted, this provision as to hight of entrance of hot air shall not apply. Halls, office rooms, laboratories and manual-training rooms may have direct-steam radiators, but direct-steam heating is forbidden for study schoolrooms, and direct-indirect steam heating is permitted. All schoolrooms shall be provided with ventilating ducts of ample size to withdraw the air at least four times every hour, and said ducts and their openings shall be on the same side of the room with the hot-air ducts.

"Whenever, for any cause, the temperature of a schoolroom falls to 60 degrees Fahrenheit or below, without the immediate prospect of the proper temperature, namely, not less than 70 degrees Fahrenheit being attained, the teacher shall dismiss the school until the fault is corrected."

The committee is informed on good authority that this year Nebraska had a very satisfactory bill prepared for presentation, but it did not pass. Some of the spirit of the law is to be found in the following requirements which are now a part of their State laws: In cities of the metropolitan class (100,000 or more population) and in cities of the first class (40,000 to 100,000) mention is made that "proper ventilation shall be provided." The words "proper ventilation" are not defined in any way, neither is there any statement defining the persons involved nor the penalty to be inflicted for nonfulfilment of requirement. The laws are very satisfactory concerning safety from fires, overcrowding, etc., but touch lightly upon pure air.

The health program recently proposed by the Nebraska Association of School Principals and Superintendents has a good ring to it. It requests, as compulsory, ventilating heating plants, cleaning and disinfecting of schoolhouses at least twice each year, submission of all schoolhouse plans to a State architect for approval, medical inspection of school children and medical inspection of all school teachers.

In Wisconsin a factory-ventilation bill was introduced this spring which reads in part as follows: "In factories, mills, workshops, mercantile or mechanical establishments, the windows shall be so arranged that they will permit the circulation of fresh air from the outside of the building at all times and shall be so constructed as to prevent direct drafts from striking the employees working within. Where the circulation of fresh air cannot satisfactorily be secured through an arrangement of the windows, any system of ventilation that will keep the air therein free from substances and qualities injurious to the health or comfort of the employees, either by fans, suction devices and the like, which shall be approved by the bureau of labor and industrial statistics, may be installed.

"Every factory inspector and every assistant factory inspector charged with the inspection of factories, mills, work-

*Abstract of report of committee on Compulsory Ventilation to American Society of Heating and Ventilating Engineers, Chicago, June 6 to 8.

shops, mercantile or mechanical establishments, shall investigate the system of ventilation in every plant inspected, and wherever same is not found to comply with the provisions of this act, notice thereof shall be given to the owner or owners thereof, or to the officer or officers, if said factories, mills, workshops, mercantile or mechanical establishments be corporations."

Kansas recently passed a compulsory ventilation law for theaters, picture shows, churches and other public buildings, of which the following is an abstract: "Section 4. It shall be unlawful for the owner, proprietors or lessee to operate any theater, picture show or place of amusement in any structure, room or place in the State of Kansas which structure, room or place is capable of containing 50 or more persons unless the system of ventilation is capable of supplying at least 30 cubic feet of fresh air per minute per person therein.

"Section 5. All structures, rooms or places used for the purpose mentioned in section 4 of this act having less than 500 cubic feet of air space for each person, and all rooms having less than 2000 cubic feet of air space for each person in which the outside-window and door area used for ventilation is less than one-eighth of the floor area, shall be provided with a draft fan or other artificial means of ventilation installed so as to force the stagnant air outward from said structure, room or place. In the end of the room opposite said fan an inlet ventilator shall be provided of sufficient size to admit the required amount of fresh air as provided in section 4 of this act. Inspection is to be made at least once every six months, and failure to comply with the law makes the proprietor, lessee or manager subject to a fine of $10 per day for such failure."

On March 6, North Dakota adopted a compulsory-ventilation law applying principally to schools and assembly rooms. The following are extracts:

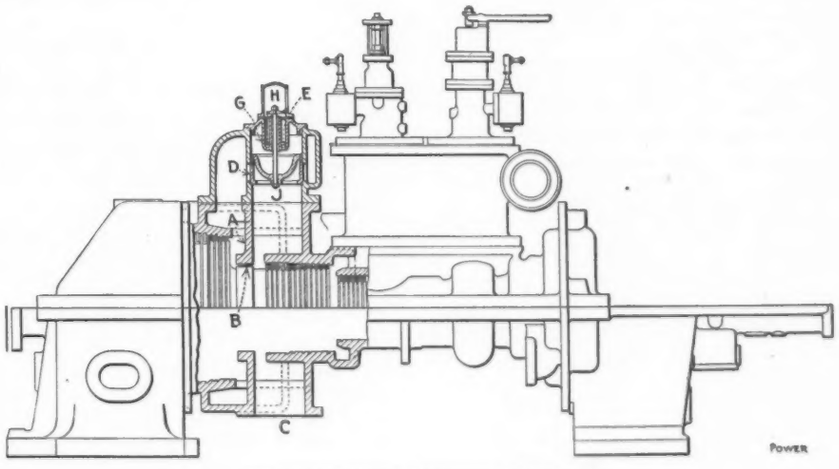
"Section 1. No building which is designed to be used in whole or in part as a public-school building shall be erected until a copy of the plans thereof has been submitted to the State superintendent of public instruction who for the purposes of carrying out the provisions of this act is hereby designated as inspector of said public-school building plans and specifications, by the person causing its erection by the architect thereof; such plans shall include the method of ventilation provided thereof, and a copy of the specifications therefor.

"Section 2. Such plans and specifications shall show in detail the ventilation, heating and lighting of such building. The State superintendent of public instruction shall not approve any plans for the erection of any school building or addition thereto unless the same shall provide at least 12 square feet of floor space and 200 cubic feet of air space for each pupil to be accommodated in each study or recitation room therein. All ceilings shall be approved by him unless provision is made therein for assuring at least 30 cubic feet of pure air every minute per pupil and warmed to maintain an average temperature of 70 degrees Fahrenheit during the coldest weather, and the facilities for exhausting the foul or vitiated air therein shall be positive and independent of atmospheric changes.

"Section 5. No wooden flue or air duct for heating or ventilating purposes shall be placed in any building which is subject to the provision of this act, and no pipe for conveying hot air or steam in such building shall be placed or remain within 1 inch of any woodwork, unless protected by suitable guards or casings of incombustible material."

Westinghouse Automatic Bleeder Turbine

The accompanying engraving shows in section a modification of the Westinghouse turbine which was exhibited to the members of the National District Heating Association at the time of their recent visit to the Westinghouse works. The turbine is adapted to be bled at one of the intermediate stages, steam being taken from it as is often done from the receiver of a compound engine for heating or industrial purposes.



WESTINGHOUSE BLEEDER TURBINE

A partition is provided at *A*, packed at the shaft with the labyrinth packing *B*; a connection is made at *C* to the heating system and that steam which is not drawn off for its demands passes through the passage controlled by the valve *D* to the low-pressure end of the turbine and the condenser.

The valve *D* is controlled by the pressure in the chamber *J* and may be set by dead weighting it at *H* to maintain any desired pressure in the heating system. The piston *E* inclosed in an oil-filled chamber is provided to dampen the movements due to sudden fluctuations in pressure. If the pressure in the chamber *J* should fall, whether by reason of a greater demand for steam for heating or a lessened supply through the turbine, the valve *D* will move toward its seat, allowing less steam to go through the lower stage of the turbine. Conversely, if the pressure in *J* rises, the valve will open wider and relieve the pressure by allowing more steam to go through the low-pressure end to the condenser.

In the production of coal Colorado ranked first among the States west of the Mississippi and seventh among all the coal-producing States during 1910. Colorado's increase in tonnage was the largest and was more than one-third of the total increase made in the seven States comprising the Rocky Mountain and Great Plains provinces. In the Mississippi Valley States the production in 1910 was materially cut down by the miners' strike. The cessation of operations among the miners in the Southwestern States created an unusual demand upon the mines of Colorado, New Mexico and Wyoming, the demand coming principally from the railroads running between the Rocky mountains and the Mississippi. There was also a better demand for domestic fuel and considerable quantities of coal for winter use were stored in the cellars of householders.

The miners' strike caused an increase in Colorado's coal production of 11.73 per cent., from 10,716,936 short tons in 1909 to 11,973,736 tons in 1910. The value increased from $14,296,012 to $17,026,934, a gain of 19.1 per cent. The average price per ton advanced from $1.33 in 1909 to $1.42 in 1910.

Low-priced men are high-priced luxuries in all departments of all industries, but in no class of work is this needless indulgence so costly in dollars and cents as it is in the power plant.

Stationary Engineers Frolic

The local National Association of Stationary Engineers, of Portland, Ore., held its third annual "frolic" at Golden Gate park, Sunday, July 16. The steamer "Joseph Kellogg" conveyed the members, their families, and friends to the grounds.

The program was one devoted to sport, ranging from contests of skill, with prizes offered to stimulate interest, to a ball game between the engineers and the cigarmakers of the city. An orchestra contributed to the enjoyment.

The committee of arrangements was comprised of the following members: Frank Akers, William Etchell, John Faulkner, F. W. Kroll, James Maguire, William Mackenzie, W. H. Murphy and C. Nern.

A large attendance made the outing a great success.

Disastrous Turbine Explosion

At the time of going to press it is reported that a 5000-kilowatt Curtis turbine at the Riverton station of the Illinois Traction Company has exploded, resulting in the deaths of two men and severe injuries to two others. A more detailed account of the accident will appear in our next issue.

PERSONAL

Osborn Monnett, late Western editor of POWER, with headquarters at Chicago, has been appointed smoke inspector for the city of Chicago.

Joseph H. McNeill, late chief inspector of boilers for Massachusetts, has been made a duputy commissioner, with increased authority and remuneration.

Raoul Beauvais, the five-year old son of Alfred Beauvais, an engineer of Central Falls, R. I., disappeared on June 7, and is thought to have been kidnapped by a band of gypsies. The boy is 3 feet 6 inches tall and of dark complexion, having black hair and dark brown eyes. The mayor of Central Falls has offered a reward of $100 for information that will lead to his return and the apprehension of the kidnappers.

OBITUARY

James C. Brooks, president of the Southwark Foundry and Machine Company, died on the morning of July 18 in the Pennsylvania hospital. He was stricken with acute heart trouble and, while he rallied, the improvement was only temporary.

Mr. Brooks served throughout the Civil War and attained the rank of major. At the close of the war he entered mercantile life, but after some years became associated with William Sellers & Co., of which firm he became a partner. He severed his connection with that firm in 1887 to take the presidency of the Southwark Foundry and Machine Company, and held that office until the time of his death.

George Farrington Hughson, president of the Hughson Steam Specialty Company, of Chicago, died Wednesday morning, July 19, at his residence, 5116 Woodlawn avenue. Mr. Hughson was born March 25, 1860, at St. Paul, Minn., and was 51 years old at the time of his death.

He had lived in Chicago for twenty-three years and during that time was prominently identified with the steam-specialty business, being for a number of years vice-president and general sales manager of the John Davis Company. About two years ago, on the retirement of the latter company from the steam-specialty field, he took over the line of goods handled by this firm and formed the Hughson Steam Specialty Company. He was a member of the Illinois Athletic Club, South Shore Country Club, Glen Oak Country Club and the Western Trades Gulf Association.

A widow and one son, Harry H. Hughson, survive him.

NEW PUBLICATIONS

CONTINUOUS-CURRENT MACHINE DESIGN. By William Cramp. Published by D. Van Nostrand Company, New York, 1910. Cloth; 260 pages, 5½ x8½ inches; 137 illustrations; many tables. Price, $2.50.

This is one of the most practical textbooks that has ever come to the reviewer's desk. The author is an experienced designer as well as a college lecturer, and the combined practices eminently equipped him for producing the present work.

To get the least attractive part of the task done first, on the same principle that incites the small boy to save his best apple until the last, the reviewer calls attention to the following more important defects:

On page 15, the statement that magnetic densities at polefaces and teeth roots "cannot change much" from the values 54,000 and 146,000, respectively, is, to an experienced designer, obviously unwarranted.

The vertical scale of Fig. 5 gives one-tenth of the correct values, which should therefore be 10, 20, 30, etc., where the figures now read 1, 2, 3, etc.

The reference to Fig. 10 in the fifteenth line on page 6 should be to Fig. 7.

The factor *Rev. per min.* should be included in the numerator of the right-hand member of the equation for watts, five lines from the bottom of page 21; the fraction $\frac{6}{5}$ in Table 1 on the same page should be $\frac{5}{6}$, and the value of 30,000 for flux density in a cast-iron yoke is below good practice and inconsistent with the value adopted on page 18.

The assumption on page 22 that the product *pole diameter or width* × *number of poles* is 1½ times the product *polar bore diameter* × *leakage coefficient* is too empirical as a hard-and-fast working rule, which the author makes of it all through the book. It is good enough as a ratio to be striven for, but using it as a definite basis for all fundamental calculations (pages 84, 86, 128, 131, 184, 200, etc.) is a rather arbitrary procedure, likely to entail extensive corrections and readjustments of the preliminary values thereby derived.

In Fig. 52, page 93, conductor No. 14 should be marked II′ instead of VI′ and No. 16 should be marked III′ instead of III.

On page 96 the wording of the fourth line from the bottom should be "Then the resistance of each armature path of," instead of "Then resistance of armature circuit of," because the author means the resistance of $\frac{1}{p}$ of the wire in the winding, p being the number of field magnet poles.

On page 107, about ten lines from the top, the author says that those conductors in a two-path armature winding which lie between two brushes of the same polarity are inactive; if this were true, the entire winding would be inactive. What he evidently means is that the coil which directly connects two equipotential neutral points on the commutator is inactive. Near the bottom of the same page it is stated that a two-path winding must have an *even* number of conductors; the inference would naturally be that a multipath winding can have either an even or an odd number of conductors, which, of course, is untrue.

On page 127 in the first equation the sign "+" should be used instead of "×" in the numerator.

On page 162, the left-hand member of the second equation should be "sin. α" instead of "cos. α." Moreover, the formula for deriving the value of L_e would be less tedious to handle if it were reduced and transposed to read:

$$L_e = \frac{S}{\sqrt{\left(1 + \frac{W_t}{W_s}\right)^2 - 1}}$$

instead of the way the author states it.

On page 177, in the thirteenth and twelfth lines from the bottom, the author says a machine will have its core length "increased in almost inverse proportion for lower or higher speeds." While this is true algebraically, it is not true physically; it would be much clearer to a student if he said "increased or decreased," etc.

On page 230 in Appendix IV the statement that equation (1) for the potential

drop at the terminals of a coil is that "for a given field current" is unnecessarily limited; the equation is true for any field current whatever. The final equation for coil dimensions, on the same page, would be somewhat more logically expressed if the factor d_c were placed in the denominator of the right-hand member, since the mean length of turn cannot be known without knowing the value of d_c; the derivation of the formula, moreover, is not particularly explicit.

Besides the foregoing specific comments, it may be pointed out that the author's use of the nonstandard abbreviation "G. C. F." is unfortunate and tends to obscure; the method of procedure exemplified on page 183 and those following is not well chosen as to sequence and rather arbitrary as to interrelations; the illustrations reproduced from drawings are uniformly poor.

Having got through with the disagreeable comments, it gives the reviewer pleasure to say that the book is far and away the best one on the subject that has been published within recent years and the only one embodying individuality of treatment or presenting any really original material that has appeared since Parshall & Hobart's "Electric Generators." The chapter on the temperature rise of field magnet coils is especially good, the subject being discussed intelligently, with a view to actual conditions, instead of academically, with respect to the one set of conditions which never exists. The author is mistaken, however, in thinking that his method of taking into account simultaneously the ampere-turns, watts lost, temperature rise and coil dimensions is entirely new. The same general method was described in the *American Electrician* almost exactly ten years ago and elaborate tables were presented to facilitate the adjustment of these interdependent values.

The discussion of temperature rise in armatures and commutators is also particularly sensible and the chapters on insulation and mechanical construction are examples of highly judicious selection and clear presentation of those data which are of the most practical usefulness.

The treatment of topics which necessitate mathematics is, for the most part, as simple and direct as the nature of the case will allow; the few exceptions have been noted.

All in all, the author's work is highly praiseworthy.

CENTRIFUGAL PUMPS, THEIR DESIGN AND CONSTRUCTION. By Louis C. Loewenstein and Clarence P. Crissey. Published by D. Van Nostrand Company, New York, 1911. Cloth; 435 pages, 6x9 inches; 317 illustrations. Price, $4.50 net.

The authors have translated the work of Fritz Neumann on "Die Zentrifugalpumpen" and have adopted both the theory expounded therein and the method of calculating impellers, which is totally unsuited to the present needs of the pump designer. Thus on page 126, example 1 deals with the problem: "An impeller and guide vanes are to be designed for a multistage high-pressure centrifugal pump to meet the following conditions: Head = 65 feet; quantity = 70 cubic feet per minute."

They proceed to assume the outer impeller diameter to be 12 inches, the outer impeller angle to be 155 degrees and the number of blades to be 10. Introducing these values in typical equations evolved in the first part of the book, they find the peripheral velocity, which, combined with the impeller diameter and the usual constants, gives the initial number of revolutions per minute as 1565.

They find that the impeller belongs to a certain class which becomes characterized by certain coefficients A and B such that the number of revolutions for any quantity and head of water can be found from the equation

$$n = -W_r A + \sqrt{W_r^2 A^2 + \eta g H_n B}$$

The speed thus determined may be, except by chance, totally out of reach of the prime mover at hand, in which case the whole guessing process has to be done over.

Nowadays the pump manufacturer has a stock of standard pump-casing patterns, each capable of accommodating a limited series of pump diameters, and for each proposition it is almost invariably expected when estimating that a special impeller is to be made. Therefore the characteristics and design of that impeller must be produced promptly and correctly to suit the conditions imposed by the customer. Eventually the manufacturer accumulates a stock of impeller patterns whose characteristics have been well tested and which are classified.

The authors believe strongly in the efficiency of guide vanes surrounding the periphery of the impeller; they say: "The object of the guide vanes is to reduce gradually, with minimum shock losses, the absolute exit velocity W_a and thus transform as much as possible of the velocity head $\left(\frac{W^2 a}{2g}\right)$ into pressure." Here is an unfortunate confusion which is found throughout the book; head is pressure, and a guide vane is a plate curved to suit the design and intended to deflect the course of a stream. What is meant is that guide passages, commonly known to all pump designers as diffuser passages, are so shaped as to render possible a gradual reduction of the velocity of the water issuing from the impeller, with the object of safeguarding against shocks and eddies transforming the kinetic energy into potential energy. They appear not to realize that the water issues from the impeller at a rate of from 40 to 100 feet per second, and that when coming into contact with the walls of the diffuser passages with such a high velocity important frictional losses are bound to result, whereas, with a well proportioned exit chamber, the water is put into motion gradually, the rate being high where contact occurs with the issuing water, which spreads easily with the least frictional loss, and very low against the casing walls.

On page 83 is stated: "By exact and very careful construction, pumps without guide vanes can be made to give fairly satisfactory efficiencies." "The construction of centrifugal pumps without guide vanes is almost entirely confined to low-pressure pumps, while this construction can never find a place with multistage high-pressure pumps." Yet Fig. 267 shows a five-stage turbine-driven pump delivering 500 gallons per minute against the fairly high pressure of 600 pounds per square inch (1400 feet head) when running at 2900 revolutions per minute. This pump has no diffuser vanes nor passages, and at the official tests showed an efficiency of 58 per cent., which is very high considering the extreme conditions imposed. With more usual water conditions the efficiency of this type of pump varies from 60 to 82 per cent.

In the text the shape of blades is considered dependent upon their number, when theoretically the impeller is just as efficient, barring frictional losses, with only one as with 10 or 12 blades. For high speed and relatively low head, and with a steep characteristic curve one blade may intercept, from inlet to outlet, an angle of more than 180 degrees. Then perhaps two blades are sufficient, but that is not known at the start. At any rate, it is usual and correct to delineate the face of the blade first, then determine its thickness, after which the most suitable number of blades is selected; finally the various cross-sectional areas of the impeller passages or channels are calculated, and with these data the diametral cross-section of the impeller itself is delineated to conform to the shape or style of pump case used.

It is well known that the shape of any part of the blade has its importance and that the action of the blade upon the water must be continuous from the inlet to the outlet; that is, in accordance with the principles of the mechanics of fluids. Therefore a correct design cannot be produced, except by mere chance, by making a stab at the two extreme points and trusting to good looks for the intermediate part.

While the theoretical part of the book appears very weak, the remainder is exceedingly interesting and gives a very good idea of the present state of the art both in Europe and in this country.

BUSINESS ITEMS

The Pueblo Suburban Traction and Light Company, Pueblo, Colo., has ordered, through H. M. Byllesby & Co., of Chicago, from the Westinghouse Electric and Manufacturing Company, three 500-kva., oil-insulated, water-cooled, 44,000-volt transformers.

Some recent changes have been made in the personnel of the Federal Metallic Packing Company, of Boston. Clinton W. Tylee, C. W. Wheaton and Willard Staples have bought the interest of F. C. Parmenter, treasurer of the company, Mr. Tylee succeeding Mr. Parmenter as treasurer, taking office July 10.

The Richardson-Phenix Company has opened a new engineering sales office in Philadelphia, Penn., located in the Real Estate Trust building. This office is under the management of J. F. McIndoe, who has had several years' experience in general machinery lubrication. Any questions pertaining to this subject will be given prompt and careful attention at this office.

The Parker Boiler Company, Philadelphia, Penn., has recently received the following orders: Victor-American Fuel Company, Gallup, N. M., one 300-horsepower; Smaltz-Goodwin Company, Philadelphia, shoe manufacturer, two 177-horsepower; Pacific Gas and Electric Company, Oakland, Cal., four 773-horsepower, with Parker superheaters; State Normal School, Valley City, N. D., one 262-horsepower boiler.

The Peterson Engineering Company, lubrication engineers, with offices in the Hudson Terminal building, New York, and First National Bank building, Chicago, announce that it has taken over from the American Engineering and Manufacturing Company, Inc., of Philadelphia, Penn., the exclusive sale of the Imperial elevator guide lubricator, manufactured by the latter company. This device will now be known as the Economy elevator guide lubricator. Recent improvements in this lubricator, it is claimed, enable it to effect an economy of 10 to 15 per cent. in the power consumption of elevators, due to the thorough lubrication of the elevator guides, causing a reduction in the fire hazard, increasing the lifting capacity of the elevator, reducing the oil or grease consumption from 200 to 300 per cent., and eliminating all danger of life and limb, necessitated by the old method of hand-swabbing elevator guides from the top of the car. Interesting data and publications on this elevator-guide lubricator are now ready for distribution.

NEW EQUIPMENT

Northboro, Mass., will extend its water system.

Edmonton, Alberta, will equip a large new pumping station.

Paul Ackerly, Vernon, Conn., will install boiler and engine.

Hubbard, Ohio, will soon install a municipal water plant.

Oak Harbor, Ohio, will install a municipal waterworks plant.

Port Stanley, Ont., will equip a new hydroelectric station.

Milltown, B. C., will install a new power and heating plant.

Watsonville, Cal., is planning to install a new waterworks system.

Hyde Park, Vt., will install water wheels to develop 150 kilowatts.

Independence, Ore., has voted $25,000 bonds for new waterworks system.

Chelsea, Vt., contemplates installing gravity water system for fire protection.

The Old Colony Gas Company will build a new gas plant at Weymouth, Mass.

L. B. Grandy, Mayesville, S. C., contemplates establishing a small ice plant.

Hyde Park, Vt., will install additional machinery in its electric-lighting plant.

R. Askins, Pratt and Illinois streets, Indianapolis, Ind., will install new boiler.

The Delaware & Hudson Railroad will erect a large coal pocket at Schenectady, N. Y.

The Columbia Gas and Light Company, Cincinnati, Ohio, will erect a large new plant.

Fire did $18,000 damage at the plant of the Babcock Ice Company, Evansville, Ind.

The Massachusetts Wharf Coal Company will build a new coal pocket at Allston, Mass.

Armour & Co. will erect a $75,000 cold-storage plant on Seventh street, San Diego, Cal.

The capacity of the municipal lighting plant at Lawrenceburg, Ind., is to be increased.

The Hillsboro (Ohio) Light and Fuel Company is in the market for an absorption ice machine.

The Enamel Brick and Concrete Company, Salt Lake City, will erect a new boiler-plant addition.

Medicine Hat, Alberta, will buy new pumps, boilers, etc., for extensions to its waterworks.

Newton, Iowa, will install a 250-horsepower water-tube boiler in the municipal light plant.

The Sauk Rapids (Minn.) Water Power Company will erect an electric-light and power plant.

Darling & Co., Center avenue and Forty-Fifth street, Chicago, Ill., will build a new boiler house.

A new power plant and laundry will be built at the Good Samaritan Hospital, Cincinnati, Ohio.

Sumas, Wash., will vote on issuance of bonds for municipal electric-light, power and heating plant.

Lindsay, Cal., has voted bonds for $55,000 for waterworks plant and $75,000 bonds for sewer system.

Holyoke, Mass., will call for bids for installing a boiler house and steam plant at the city farm.

The power and lighting plant on John Arbuckle's farm at New Paltz, N. Y., was destroyed by fire.

The Edison Electric Company will build a $35,000 substation at 3442-44 Calumet avenue, Chicago, Ill.

The Seattle (Wash.) Brewing and Malting Company is having plans prepared for a new cold-storage plant.

The Pavlak Mining Company, Jarbidge, Nev., is planning to erect a 250-horsepower hydroelectric plant.

The city of Cleveland, Ohio, has the construction of a $2,000,000 electric-light plant under consideration.

The Olean (N. Y.) Electric Light and Power Company is preparing plans for a new power plant at Ceres, N. Y.

The Lenox (Mass.) Water Company contemplates issuing $40,000 bonds for improving its water system.

The Indiana & Michigan Electric Company, South Bend, Ind., will construct a power house at Elkhart, Ind.

The power plant of the Mishawaka Woolen Manufacturing Company, South Bend, Ind., collapsed. Will be rebuilt.

The St. Louis (Mo.) Independent Packing Company will erect a three-story addition to its refrigerating building.

The State Board of Control, Olympia, Wash., will erect a new power plant at the Veterans' Home, Port Orchard.

The plant of the South Pittsburg (Penn.) Electric Light and Power Company was destroyed by fire. Will be rebuilt.

H. Delano, Corpus Christi, Tex., is planning the erection of an ice plant at Tucson, Ariz. Initial capacity, 50 tons daily.

The Winooski River Power Company, Waterbury, Vt., has awarded contract for the construction of a dam and power house.

The Toronto Niagara Power Company will buy $500,000 worth of machinery for its new power house at Niagara Falls, Ont.

Power-plant equipment will be required for the 14-story building to be erected for the Buffalo (N. Y.) General Electric Company.

Boston, Mass., is receiving bids for furnishing a refrigeration plant using brine system and a Corliss engine driven compressor.

The Washington Water Power Company, Spokane, Wash., is planning to install a lighting and power system at Spokane, Wash.

The State of Massachusetts has voted $5000 for the purpose of installing new boilers, etc., in the State prison at Charlestown, Mass.

The B. & R. Rubber Company, North Brookfield, Mass., will install three boilers and a tandem-compound engine for additional power.

The Portland (Ore.) Railway, Light and Power Company will make improvements to its substation on First street to cost about $10,000.

The San Francisco (Cal.) Gas and Electric Company is having plans prepared for a new power plant at Sacramento to cost about $70,000.

The San Joaquin Light and Power Company, Fresno, Cal., is erecting a new substation at Clovis and will erect another at Lemoore.

The Hamilton (Ohio) Ice Delivery Company has secured site for a new plant in which modern ice-making machinery will be installed.

Power-plant equipment will be required for the new hotel building to be erected by the Dallas (Tex.) Hotel Association to cost about $650,000.

The Thompson-Snow Amusement Company, Los Angeles, Cal., will install an artificial ice-skating rink and refrigerating plant at Luna Park.

The Northern Idaho & Montesano Power Company, Newport, Wash., is planning the installation of an electric-lighting system at Priest river.

Boiler house of the Germantown Ice Manufacturing Company, at Belfield avenue and Haines street, Philadelphia, Penn., was destroyed by fire.

The Barrett Manufacturing Company has taken out a permit for a boiler house to be erected at Bermuda and Margaretta streets, Philadelphia, Penn.

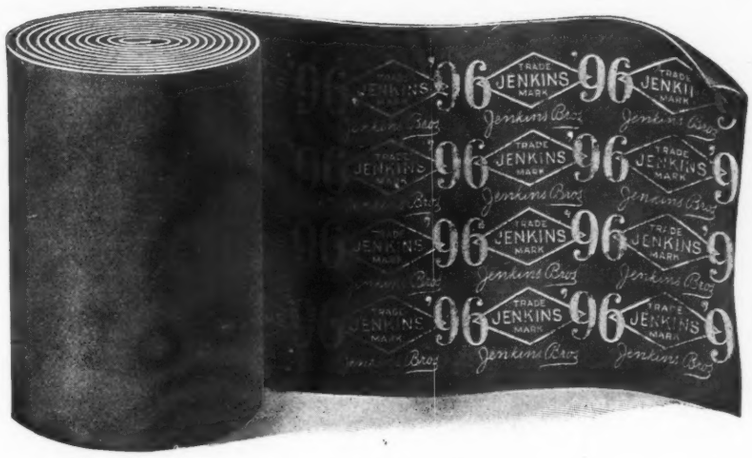
The Bremerton & Charleston Light and Fuel Company, Bremerton, Wash., contemplates installing a power and lighting system at Port Orchard, Wash.

The Cedar Rapids & Iowa City Railway and Light Company, Cedar Rapids, Iowa, will install two new boilers, one turbine and make other improvements to its electrical equipment.

Plans have been completed by P. O. Kellholtz, of Baltimore, Md., for new 35,000-horsepower power plant to be erected at Security by the Western Maryland Power Company.

"Talking Points" can befuddle the issue with imaginary benefits and hide the real ones.

Jenkins '96 Packing Needs No "Talking Points"



It gives packing *service*, and that is what the engineer wants and will have. It is *pure packing*, yard for yard and all the way through.

It is the ideal sheet packing because it makes tight and permanent joints which do not rot, burn or blow out, and it is easy to handle.

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Flexible without cracking, conforms perfectly to uneven surfaces, and its *unequaled durability* has been proven in thousands (not hundreds, but thousands) of steam plants. Use it on the worst joint you have, and we'll take the risk of its proving unsatisfactory by refunding the money if it should.

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Cut from the JENKINS '96 PACKING, to any size or shape and in any quantity. No waste when ordered in this way. Give inside and outside diameter and thickness and if shape is irregular, send drawing of template.

Light in weight and therefore lower in price per yard than packings which sell at a cheaper price per pound. Credit allowed for cuttings returned.

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Trimont Mfg. Co..... 78
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"Knowing of the I. C. S., I decided to take up a Course and push to a better position. July 9, 1906, I began a Course of Complete Steam Engineering, and 2 months later I was rewarded with an increase in wages of $5 a month. November 1, 1906, I was offered a position in the same plant at a salary of $90 a month. January 30, 1907, I accepted a position at $115 dollars a month, and in July of the same year my salary was increased to $150 a month.

"In the meantime I continued with my studies, completed my Course and received my diploma January 6, 1909, with a very creditable average of 99¾ per cent. on the complete Course.

"In October, 1909, I again accepted a position netting me $175 a month, and on June 1, 1910, my salary was increased to $300 a month—about 550 per cent. more than the salary I received when first taking up my Course.

"I can only find words of the highest praise for the training the I. C. S. affords."

The complete expenditure, including cost of Course, postage, drawing outfit, drawing paper, answer paper, pens, pencils, etc., was only $86.27.

Would you be willing to make a similar investment that would increase your salary 50, 100, 200, or 500 per cent.?

Every month there are received at the I. C. S. upwards of 300 voluntary letters from students telling of positions bettered and salaries increased through study of I. C. S. Courses. These men are not men of genius—they are not the sort of men known as "gifted," "naturally bright," etc. They are plain men who have applied themselves diligently to their work, and their rise in the world is due solely to spare-time study. The lives of such successful students should be your inspiration. These men are now making their mark industrially and commercially; they have sown the seed of education by enrolling for I. C. S. Courses; they have cultivated knowledge by properly using their spare time on these Courses; and today they are reaping a harvest of dollars, happiness, and contentment.

If you are not satisfied with your present position mark and mail the attached coupon. Doing so will cost you only postage and will place you under absolutely no obligation.

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Please explain, without further obligation on my part, how I can qualify for a larger salary in the position, trade, or profession before which I have marked X.

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*City*_____ *State*_____

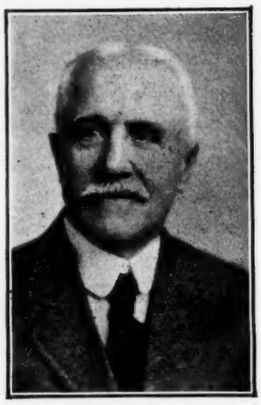
*Present Occupation*_____

The "Eureka" Square Deal

Published every other week in the Interests of Honesty in the Packing Business.

By James L. Robertson.

The Insult Offered You By The Grafting Packing Manufacturer



JAMES L. ROBERTSON

This "graft" campaign has developed some queer things.

For one thing, we've got the bribe-offering manufacturer scared.

And, like a coyote, when you've got 'em cornered, they develop a sort of desperate bravery and fight back.

For instance, at least three of them cut out these "square deal" talks and furnish their salesmen with them.

Then the salesman endeavors to prove to engineers that we are condemning the profession generally and that engineers should retaliate by not using **Eureka Packing.**

Here, then, are two insults offered engineers by these manufacturers, besides their regular business of offering graft.

The first is to insult your intelligence by intimating that you cannot correctly interpret these "square deal" talks.

You know, if you've read these regularly, that no one in the world has a higher regard for the intelligence and honesty of engineers than I have.

You know I have always expressed my belief in the great majority of the profession. You know that I know, and have repeatedly said so, that the grafter represents but a small portion of the men in the great field of power production and transmission.

Yet, in the face of your knowledge, these grafting manufacturers, squirming at both ends like a worm held down in the middle, are attempting to tell you that you don't know a thing when you see it.

Their second insult is asking you to *boycott* a concern which is working *against* graft methods.

In other words, set your seal of approval on concerns which *are* doing a *crooked* business.

Truth is, these manufacturers are in bad. They know they're in the wrong; they know that every bribe offered is another blow aimed at the self-respect of the engineering profession and they are in the difficult position of the man who tries to square himself with the fellow he's just knocked down and walked on.

On the other hand, I feel that I've got the backing of every engineer who is desirous of seeing the graft game wiped out.

I know that you realize that it is only a matter of time, if it continues, when graft will get a stranglehold on the profession and the majority will suffer for the sins of the few.

And so, these articles are in the nature of warnings; they are appeals to *you* to help me and other square deal packing manufacturers to wipe out this graft evil. Let's get business on an honest basis. Let us put the grafter and his near-good packing where he belongs—in the limbo of past things.

Buy your packing from square dealers. I hope you'll buy **Eureka,** of course. You'll get a packing which is worth every cent you spend for it. It has always stood the test for value. But, whatever you buy, give the rebuke to the men who are attempting to make the engineering profession a catspaw to pull their chestnuts from the fire.

Gum Core

Eureka Packing is sold throughout the world by reputable dealers. Ask yours. If he hasn't got it in stock and can't supply it, send to us direct. We'll pay freight on 10 lbs. and over east or south of Omaha. We make 39 varieties for all purposes and the line comprises all styles and shapes.

Eureka Packing—39 Varieties—Have You A Catalog?

Eureka Packing Co., (Jas. L. Robertson, President.) 76-78 Murray St., New York

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KEYSTONE TRADE MARK REGISTERED U.S. PAT. OFF.

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Because there are some things it will pay you to learn about Keystone Grease.

For Keystone Grease is all pure lubricant—composed of petroleum oils that are natural friction-reducers, scientifically put together.

Keystone Grease is insoluble in water, it contains absolutely nothing that is injurious to bearings, it has the same consistency winter and summer.

Keystone Grease is applied to bearings by pressure grease cups. The development of frictional heat is not required to cause the grease to feed. The original density of Keystone Grease never changes under the severest conditions of speed and pressure and atmospheric heat and cold. Keystone Grease holds the world's record for the lowest co-efficient of friction. No other lubricant on the market can compare with it in quality—a lubricant with thirty years' reputation back of it.

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Please send us a large size sample of Keystone Grease, sufficient for testing purposes, and one Brass Grease Cup and Free Engineer's Cap. It is thoroughly understood that no charges whatsoever will be made for sample, cup or cap, and all express charges will be paid by you.

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Its width . . . . . Combined horse power of engines . . . . . .
Tap size of cup . . . . . .
FIRM. . . . . .
Per . . . . . .
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Size cap required . . . . . **CUT OUT THIS COUPON AND MAIL IT TO-DAY** Dept. B—8-8-11

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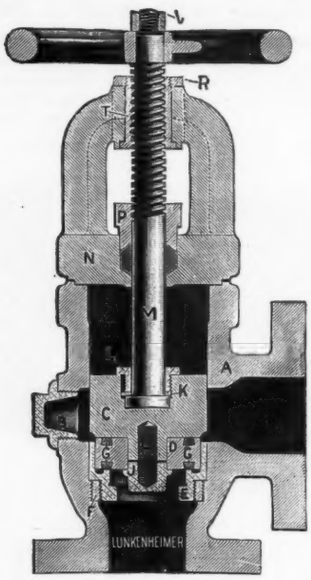
well known in the engineering field.
It is synonymous with quality

"Duro"

is a name synonymous with durability,
and which when associated with
Lunkenheimer and



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is immediately recognized by engineers as the
trade name of a valve without an equal.

Lunkenheimer "Duro" Blow-off Valves

are guaranteed for 250 pounds working pressure. The body is made of cast iron having a tensile strength of 25000 pounds per square inch. And the bronze used contains a high percentage of copper and tin.

One of the principal advantages in the design of these valves lies in the construction of the seat and disc, which provide self-cleansing seating surfaces so that any scale or grit lodging on the face of the seat will positively be washed off before the disc is firmly seated, thereby insuring a perfectly tight valve.

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2

Unless Your Boiler Is In A Healthy Condition

You are going to suffer. ¶ If you are not well, physically, you know how your work suffers. ¶ If you have a headache your work is not up to standard. ¶ If you are worried about something, you are not as fit as when your mind is absolutely care free. ¶ And to that extent your boiler is human. ¶ Keep the tubes, the arteries of the boiler, free of scale, keep them absolutely clean—and your boiler can always be counted on for the best that there is in it. ¶ But, let scale incrust the tubes, and you are in for untold troubles. ¶ The heat is prevented from getting to the water. ¶ The tubes will bag, the ends will burn, you will have larger coal bills, you will have larger repair bills, and your boiler itself will wear out sooner than it should. ¶ Keep the tubes in clean condition, keep scale out of the boiler by treating feed water with Dearborn Treatment. ¶ Dearborn Treatment is made after a thorough analysis of your feed water in our well equipped laboratory, a corner of which is shown in the picture. ¶ That's why it accomplishes such satisfactory, such lasting results. ¶ Send us a gallon of your feed water; we will analyze it and tell you the cost of Dearborn Treatment that will keep your boilers in constant good health—Send the gallon today.

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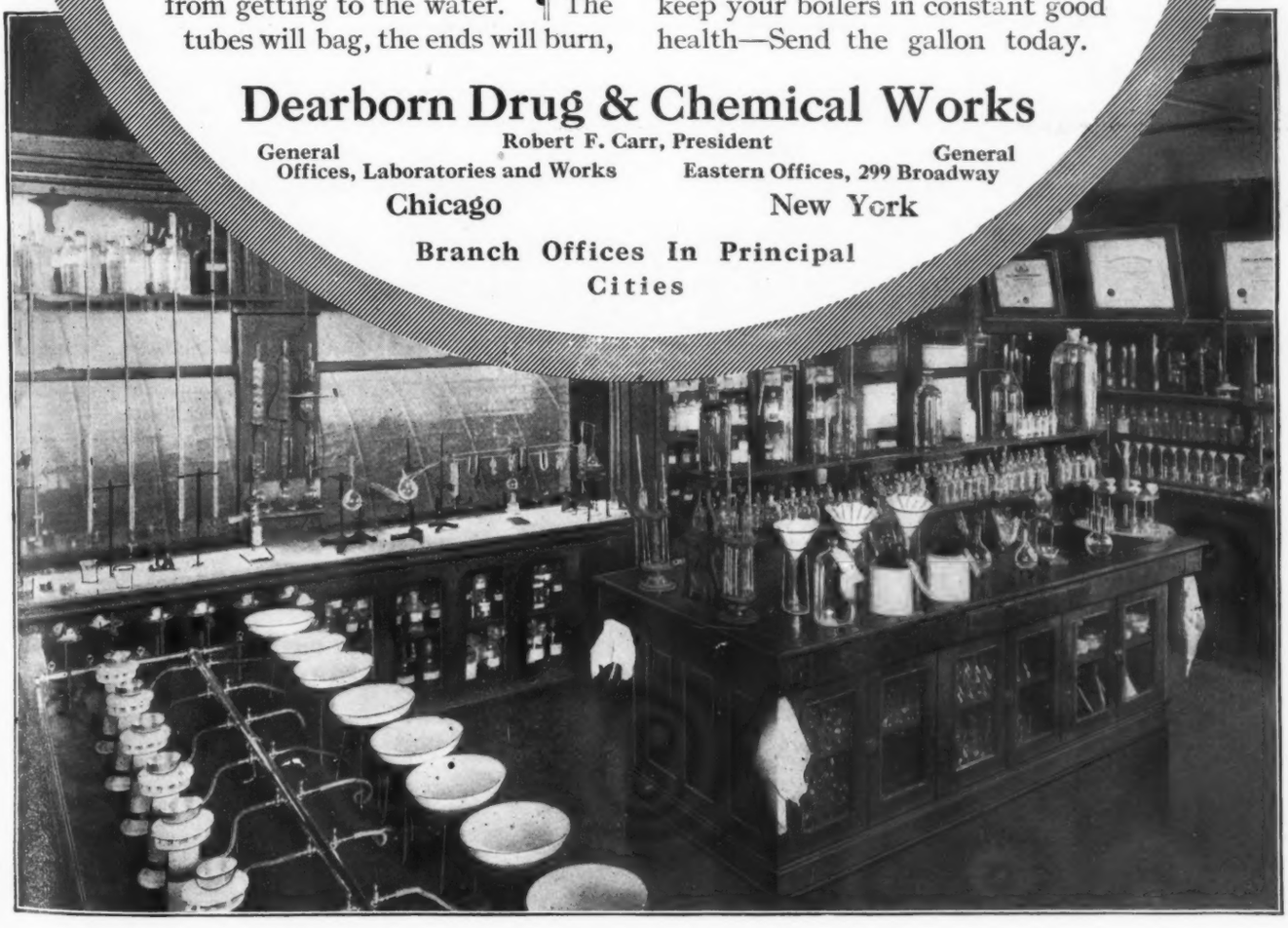

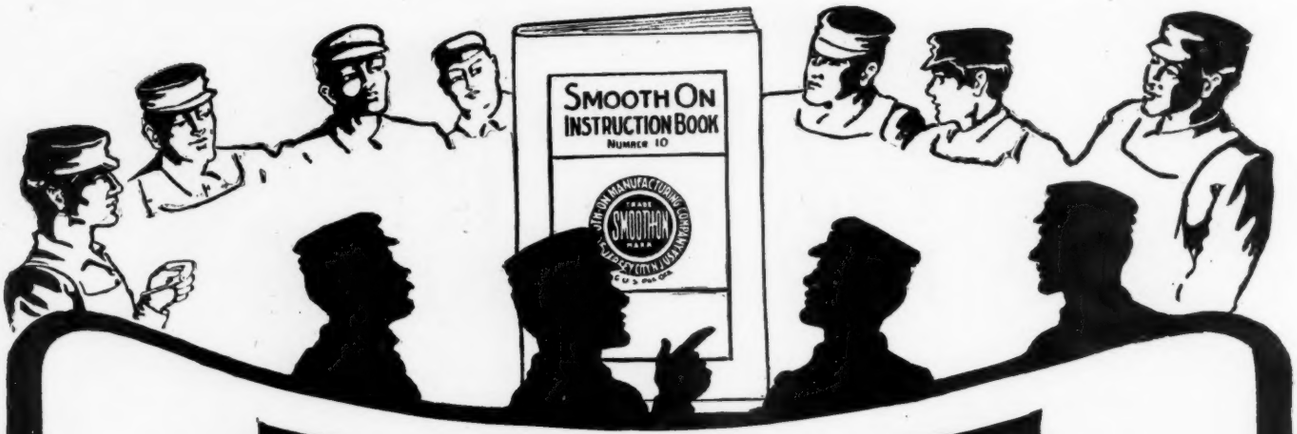

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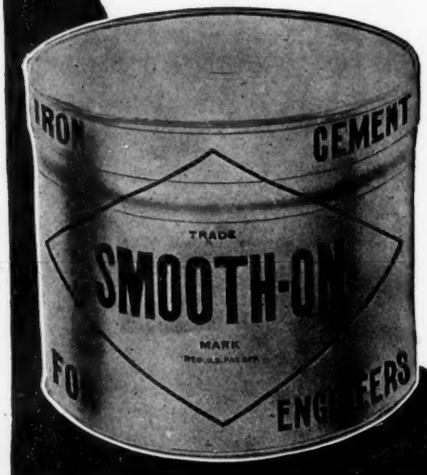
INSTRUCTION BOOK

This book should be within instant reach of every engineer. It tells clearly, by photograph and formula, how to use the well-known Smooth-On Iron Cements in repairing boilers, engines, castings, tanks, joints, etc.

Used according to instructions, Smooth-On Cements will save more actual time and money in the engine and boiler room than any single product manufactured. Their uses are innumerable, and their repairs absolutely permanent.



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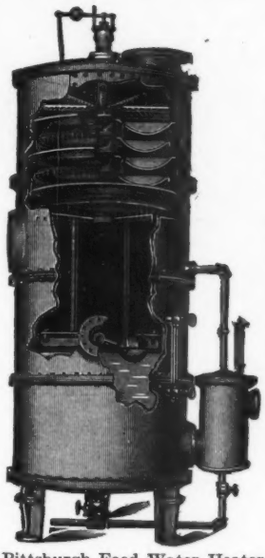
Peculiar Because It's Good



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When you need a Strainer, look up our entire Strainer Line. We make them in all sizes; for all pressures, for all kinds of service.

We want to give YOU full information about Elliott Reducing Valves; Steam Traps; Liberty-Greenaway Separators; Pittsburgh Feed Water Heaters; Feed Water Regulators; and Liberty Oil Purifiers.

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Elliott Company

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Cyclone Cleaner

you, or the fellow who sold you a cheap tube cleaner? We think he holds it, and it's growing heavy—With *your* money—

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TELL US the type of your boilers,
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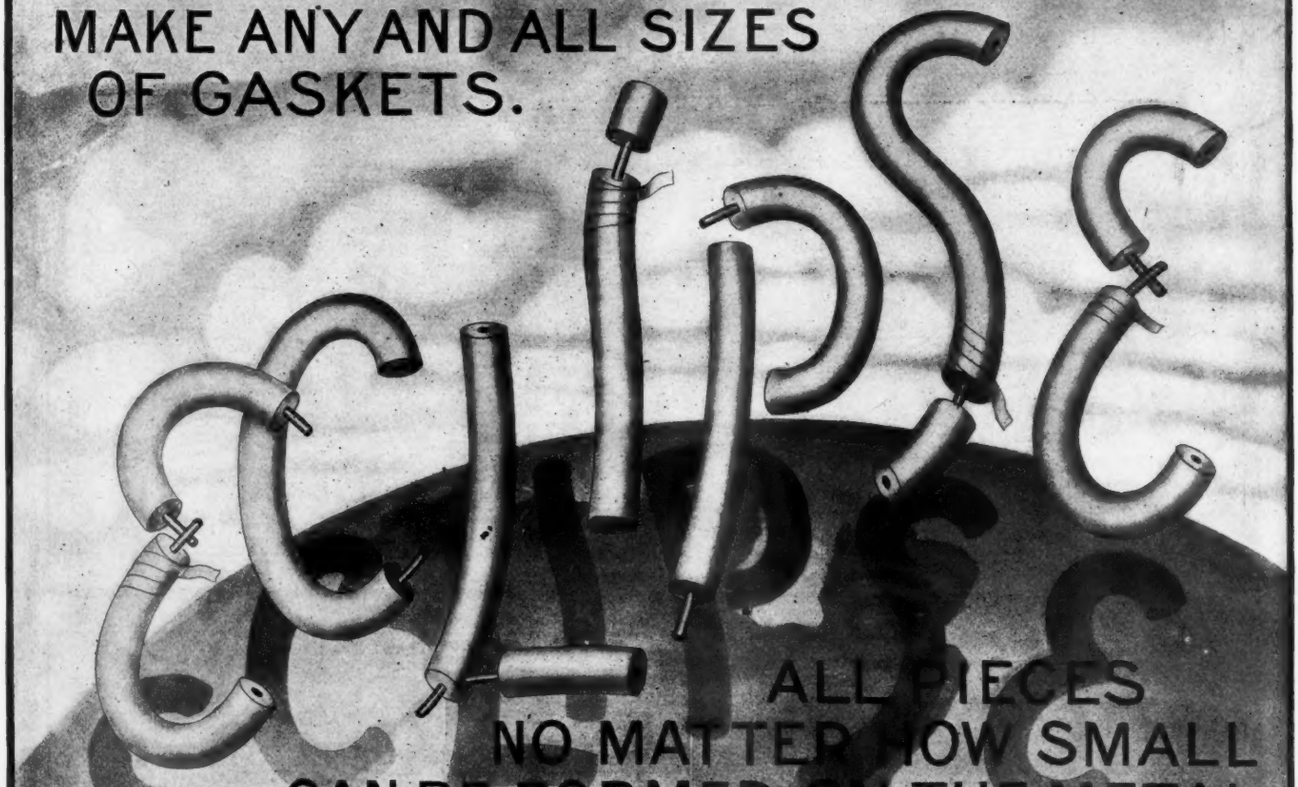

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THE Gasket or Joint made up from the Celebrated Garlock Style No. 900 Sheet is a guarantee of safety and economy.

Would be glad to place a *Trial Gasket* with you for *Free Test.*

Write us at once regarding this offer.

Have you a copy of our catalog?

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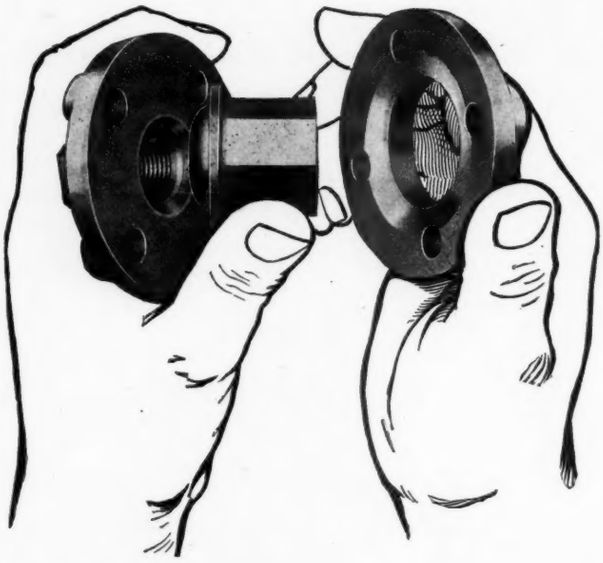
The Jefferson 3-Part Flange Union



Makes Tight Joints Easy

If You Want To Try The Jefferson 3-Part Flange Union

If you actually want to test the best flange union made, send us a trial order. We'll guarantee you satisfaction.

¶ For actually to use the Jefferson 3-Part Flange Union is to best appreciate its many advantages.

¶ You will see how the Movable Collar saves time, how the elimination of the use of gaskets makes it easy to make joints *stay* tight; how in it, the necessary brass is protected from dislodgement by expansion and contraction; also from any injury whatsoever.

¶ Nothing but drawn brass tubing, instead of cast brass, is used, eliminating all danger of leaks from sand or blow holes.

¶ Its ball-shaped seat makes joints that *stay* tight and is far ahead of the common, conical shape.

¶ It is strong and durable because "the right metal is used in the right place." Its superior design makes possible permanently tight joints, even when the pipes to be connected are not in perfect alignment.

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¶ Get a copy of our new Bulletin A. It is well worth having on file.

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The Jefferson Union Company

164 Main Street Lexington, Mass.

Automatic Packing

(THEORY)

Another Packing Talk

By

"Old Bill"

It will be necessary in discussing Automatic Packing to separate the subject into two parts—theory and practice. This article deals with the theory of Automatic Packing—the next article will deal with the practice.

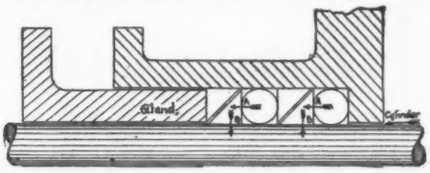
I assume that I am talking to engineers who are well acquainted with indicator cards, and the action of steam within the cylinder. For those who are not acquainted I can briefly state that steam is admitted at full pressure for only a portion of the stroke. After this fraction of the stroke has passed, the steam is cut off. The steam that is within the cylinder then expands with decreasing pressure until toward the end of the stroke, when the exhaust ports are opened and the steam pressure within the cylinder suddenly diminishes. On the return stroke, the only pressure is the back pressure caused by forcing the steam out through the exhaust. If you will recall one of the early talks of this set, you will remember that the grip or close contact of the packing with the rod in a rough way varied with the pressure to be held back, that is to say during the exhaust stroke when the pressure amounts to only a few pounds, the grip on the rod may be merely nominal. During the expansion of the steam the grip must be greater, as the pressure is greater, and during the admission of steam when the pressure is greatest the grip must be greatest.

In the case of Gland Pressure Packings, the grip is not only constant throughout both strokes, but is usually in excess of what is necessary, due to the inability of the man packing the gland to get just the right pressure on the gland. Generally this pressure is very much in excess, which, of course, makes that class of packing the poorest of all packings.

In the case of Moisture Expanding, or Heat Expanding packings the grip is caused by the swelling of the packing, due either to moisture or heat, and a grip on the rod is obtained which is more nearly just what is necessary, but the same intensity of grip is maintained throughout both strokes. It is clear that this close contact with the packing produces friction and offers resistance to the passage of the rod through the packing. This work requires steam, steam requires coal, and coal requires money, so that if there is an excessive grip or an unnecessary grip, it means an actual loss in work from which no useful result can be obtained.

The theoretically perfect packing should therefore be an automatic packing, i. e., a packing which adjusts its grip on the rod to the pressure within the cylinder. When the pressure is greatest, the grip should be greatest; when the pressure is least the grip should be automatically reduced.

This Automatic Packing, or as it is generally known, "Diagonal" Packing, is made of three parts and a surrounding sheath. This sheath is put around the packing simply to hold it in position while being inserted. It is not necessary, so far as the operation of the packing is concerned, but is necessary for convenience of insertion. We will disregard this in considering the action of the packing. The other three parts consist of a cushion and two wedges. The cushion is necessary to separate the wedges so that they can act without interfering with each other. The wedges by their sliding action produce a pressure on the rod proportional to the impelling pressure from the cylinder.



A glance at the sketch accompanying this will show that when a pressure is exerted from the cylinder along the direction of the arrow "A" it will produce a resultant pressure upon the rod along the line of the arrow "B." If the pressure on "A" is increased, the grip on "B" will be increased. If the pressure on "A" is diminished the grip on "B" will be diminished. In using packing like this the gland serves only as a barrier to keep the packing from blowing out and to offer a resistance to the second wedge so that the first wedge may slide upon it.

The patents on this original packing were assailed in the Courts, and a mass of expert testimony introduced, which was of great value in determining the real value of the packing. The most interesting testimony came from tests which were run on a vertical engine direct connected to a dynamo in which three different packings were used corresponding to the gland pressure class, the heat expanding class and the automatic class of packing. These tests were made after the engine had been run under load for some ten hours to get the packing thoroughly warmed and set into place. The load was then entirely removed and the bearings flooded with oil. As the engine was vertical, the friction of cross head, piston and valves was reduced to a minimum. The real load on the engine, therefore, was the friction in the stuffing box. As a result of the cards taken at this time it was shown that the friction developed under these conditions, with a gland pressure packing amounted to about nine per cent. of the full load; with a heat expanding packing the friction load to seven per cent; with an automatic packing the friction load amounted to a little less than four per cent. As the only conditions that were changed were those of the packing, it is evident that the saving must have been caused by the saving in friction produced by the better action of the packing. These figures have been corroborated by experiments on engines running under regular daily load. While they may not be accurate, for every engine, yet the difference in the load is such that it proves conclusively that the automatic packing is the most economical of all the packings.

To reduce this to tangible figures:

If we should take a hundred horse power engine and assume that the cost for horse power per year amounted to $40.00, we would save by using the automatic packing instead of a gland pressure packing, five horse power, which would amount to $200.00 per year, or if we used the automatic packing instead of heat-expanding, we would save three horse power or $120.00 per year. Either sum is so large that it cannot be neglected and it is very easy to deduce from these figures the conclusion that the automatic packing is not only more economical in theory, but is also more economical in practice; in fact it is considered as the best construction of packing that is offered today.

In our next article we will discuss the different forms of Diagonal Packing and more than that the proper method for the use of Diagonal Packing.

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Automatic Packing

By

The Advertising Manager

Thermoid

"99"

That is the name of the new

Thermoid Diagonal

the latest product of "Old Bill's" brain.

It beats everything heretofore put on the market in the shape of a diagonal.

Wedges cannot be torn apart, they must wear away thread by thread; consequently "Thermoid 99" will last 50 to 75% longer than any other diagonal.

Put up in spiral form only, making it easy to cut rings and insert them right.

Remember the name, "**Thermoid** 99."

Remember the price, 99c per pound.

Better send your name for a copy of the new catalog soon to be issued.

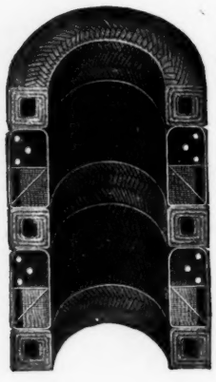
Thermoid Rubber Company

Trenton, - - - - - N. J

RINGS FROM OUR FAMOUS BRANDS.

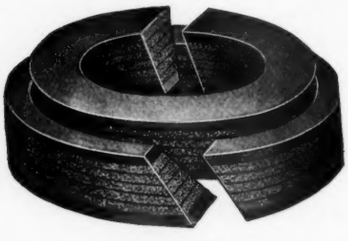
STYLE 213 STYLE 102 STYLE 101

A FEW OF THOSE SHOWN IN OUR ENGINEERS' CATALOGUE. MADE TO MEET ALL CONDITIONS OF SERVICE.



STYLE 529

STYLE 528



STYLE 201

SEND FOR OUR NEW ENGINEERS' CATALOGUE

MANUFACTURED EXCLUSIVELY BY THE

NEW YORK BELTING & PACKING CO. LTD.

91-93 CHAMBERS ST. NEW YORK

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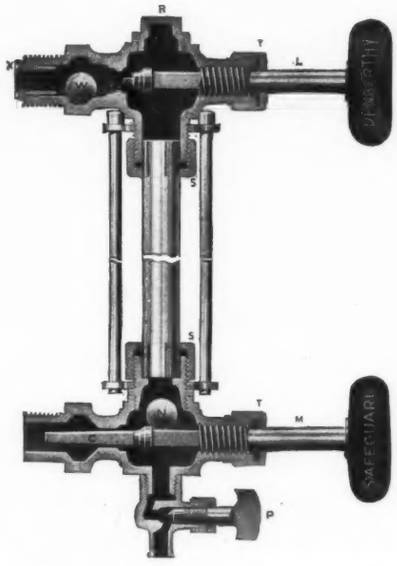
LONDON, ENGLAND, 13-15 SOUTHAMPTON ROW

Isn't Perfect Gage Glass Safety Worth $2.25 To You?

Wouldn't you be willing to pay that amount for *absolute* protection and insurance against accident and injury due to breaking of gage glasses? You know the danger—here, at last, is a dead sure, automatic remedy—

TRADE PENBERTHY MARK.



SAFEGUARD Automatic Water Gage

THIS new gage guarantees *certainty* of operation at the *proper* time.

The balls *cannot* seat unless the glass breaks because of the leak in the upper arm, and the action does *not* depend on complicated mechanism—simplicity is one of the strongest features.

All you want to know about your Water Gage is that it will operate *instantly* when necessary, and that it will *not* operate *except* when necessary.

This the "Safeguard" can be relied upon to do always—without fail.

And remember it costs only about as much as the ordinary, less desirable and non-automatic square body water gage.

SEND IN YOUR ORDER FOR ONE NOW.

If your dealer will not supply you, write us and we will ship direct. $\frac{3}{8}$" and $\frac{1}{2}$" shank, $2.25—$\frac{3}{4}$" shank, $2.75—a small extra charge being made for glasses over 14 inches long.

Write for the descriptive circular.

Penberthy Injector Company,

355 Holden Avenue, Detroit, Mich,, U. S. A.

Extract Every Heat Unit From Low Grade Fuels

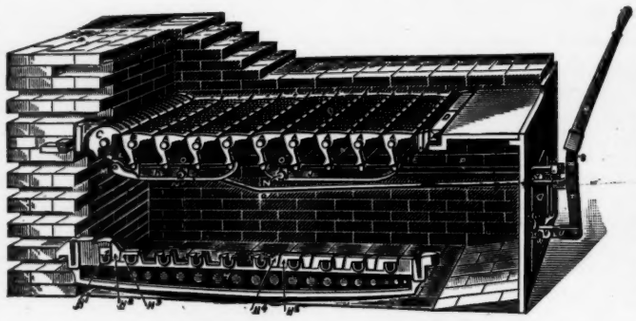


Plate No. 1. Normal Position of Grate.

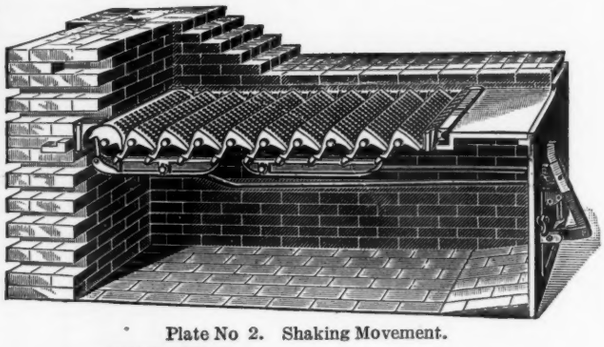


Plate No 2. Shaking Movement.

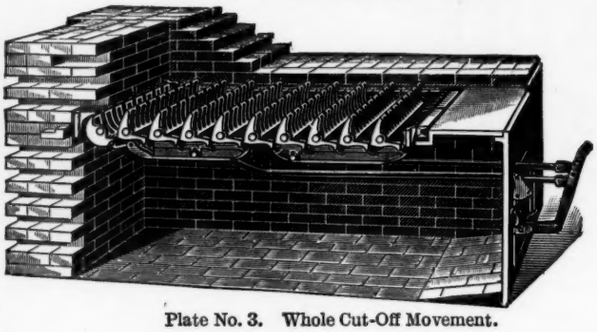


Plate No. 3. Whole Cut-Off Movement.

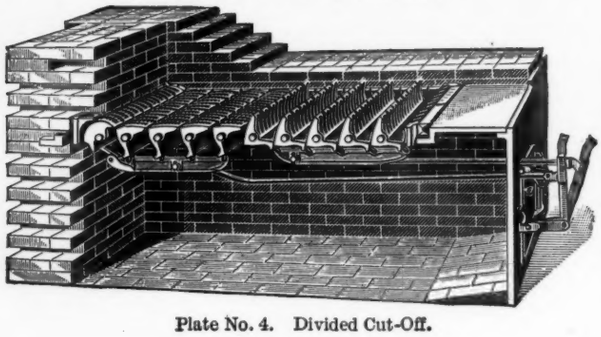


Plate No. 4. Divided Cut-Off.

McClave Grates and Argand Blowers

Are more than parts of the boiler furnace—they form a system of complete combustion.

This combination makes it possible for you to use a low grade fuel successfully.

The truth of this has been proved by the CO_2 Recorder and many other tests.

For example, No. 3 Buckwheat used on these grates with the Argand Blower will give results as satisfactory as high grade coal on ordinary grates.

Argand Steam Blower

Plates 2, 3, and 4 show the McClave movements necessary in handling without waste such cheap fuels as the lower grades of anthracite and bituminous coal. Rice, birdseye, buckwheat slack, screenings, etc., may all be used with good results.

Write us for full information — ask for Catalog "G."

McClave-Brooks Company, Scranton, Pa.

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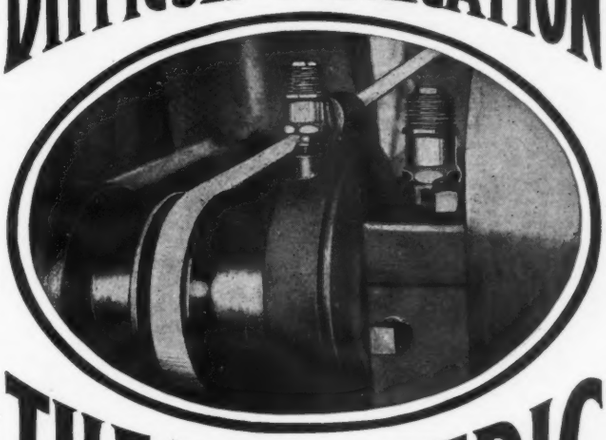
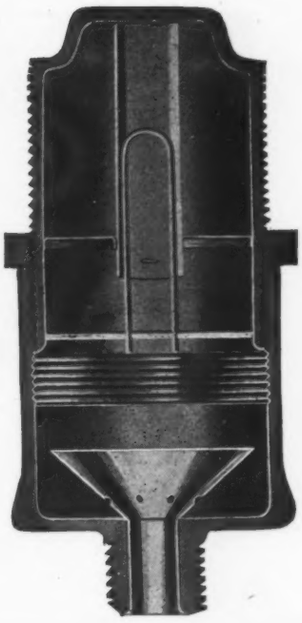
DIFFICULT LUBRICATION



THE ECCENTRIC



PHILADELPHIA COMPRESSED AIR GREASE CUPS

The best evidence of the dependability of the Philadelphia Grease Cup for *ordinary* lubrication is its complete success on those difficult parts where other cups fail.

Probably where other cups fail most frequently are the parts where the cup is subjected to extreme vibration, centrifugal force, etc.

For instance, on your crank pin or a loose pulley; or similar cases to the eccentric shown above, where there is considerable friction between the sliding surfaces as well as centrifugal force.

Engineers have had so much difficulty in lubricating such parts as these that we find they cannot believe

The Philadelphia Compressed Air Grease Cup

can accomplish this until they see it in actual operation on just such a hard job.

And it is just for this reason that we do not ask you to accept our claim.

On the contrary, to give you an opportunity to find out before spending one cent, we will give you absolutely *free* a sample Philadelphia Cup that you can put right to work on the hardest job in your plant, and prove it for yourself.

The cup is yours to keep, whether you use any more or not.

And besides giving you a cup we will give you a free sample can of any standard grease on the market.

So the entire test, together with a free sample grease cup and grease, will cost you just a 2c. stamp.

Besides, you will save 25 to 75% of the cost of lubricating the bearing on which you test the grease.

All you need do is fill out and mail us the attached coupon, stating what size tap you desire cup for and which grease you prefer from the following:

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Philadelphia Grease, manufactured by Philadelphia Grease Mfg. Co., Philadelphia, Pa.
Zorozo Grease, manufactured by F. S. Walton Co., Philadelphia, Pa.
Albany Grease, manufactured by Adam Cook's Sons, New York, N. Y.

Send the coupon right now before you forget. It's all free.

UNIVERSAL LUBRICATOR CO.

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COUPON

Universal Lubricator Co., Philadelphia, Pa.
Name .....
Firm Name .....
Street Address .....
City .....
County .....
State .....
Our buyer's name is .....
State on which bearing test will be made .....
Diameter .....
R. P. M. .....
Size of tap .....
Which grease .....
Name of dealer .....
Dealer's address .....

Power, 8-8-11

What Have You There Jim?

These Are The Four Free Samples We're Sending Out All Over The Country

If you have not received one of these free boxes from us—send the attached coupon right now, before you forget. There is no cost attached to these four samples now or later; we even prepay the expressage.

ZOROZO Grease

REG. U.S. PAT. OFF.

can be used wherever any other non-liquid lubricant is used, and upon thousands of bearings that are now lubricated by oil, and to far greater advantage in either case.

It is only because we know how valuable these articles will be to you that we can possibly afford to go to the expense of offering them all free.

Just tear out and sign the attached coupon, sending it to us at once; your box will be sent by express entirely free.

Here's Another FREE OFFER. If You Prefer This One Drop Us A Line

We will send you a barrel of Zorozo and a dozen "Philadelphia" Compressed Air Grease Cups for ninety days' free trial, and if Zorozo doesn't prove better than any grease you have ever tried, you can return the cups and what is left of the barrel and no charge will be made for the amount consumed.

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FREE SAMPLES - SIR!

Zorozo Lubricating Grease—

OXoil OX Belt Dressing

Bottle of Victoria Liquid Soap

(which is always sent as a premium with every order for Zorozo and OXoilOX)

A Philadelphia Compressed —Air— Grease Cup

from the

F. S. Walton Co.

Philadelphia,
Penn.

Or You Might Like This One Better. If So, Write us

We will send you a trial keg and charge you at the barrel rate payable in ninety days, and make you a present of 3 "Philadelphia" Compressed Air Grease Cups.

PHILA., PA.

COUPON

Gentlemen:—You may send me free Zorozo, OXoilOX, Victoria Liquid Soap and Grease Cup.

Name.....

Name of firm.....

Address in full.....

H. P. of engine.....

On what bearing will sample be tested.....

Its diameter.....

R. P. M.....

Size of tap for cup.....

POWER-8-11

"It's Doing More Than You Claimed It Would Do"

Read What They Say Of The "Burt"

Olympia Cotton Mills.

Columbia, S. C., Oct. 19, 1905.

The Burt Mfg. Co., Akron, Ohio.

Gentlemen—About three months ago we installed one of your "Unit Type" of Oil Filters and it is giving perfect satisfaction, in fact, it is doing more than you claimed it would do—

We are filtering all the waste oil from three 1500 H. P. Mackintosh Seymour Engines and by the use of your Filter we are able to save at least 10% over our old way of filtering the oil.

Your Unit Filter is well constructed and easily cleaned, and I recommend same to anyone wishing such a machine.

Olympia Cotton Mills, D. R. Harriman, Supt.

This tells the story in a nutshell. Here is truly a saving on oil consumed. Do thou likewise.

Send for our new 112-page Catalog, just issued.

The Burt Mfg. Co., 232 Main St., Akron, O., U. S. A.

Largest Manufacturers of Oil Filters in the World

We also manufacture a complete line of Exhaust Heads and Ventilators.